Computer Science in Rural California: Training, Implementation, Teaching, and Learning

Early-Phase Grant Request: Small School Districts Association of California

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A. <u>Significance</u>

With an EIR Program-Early-Phase Grant, the California Small School Districts Association (SSDA) seeks to field-test an innovative ***Computer Science (CS) Rural Implementation Model*** to better prepare teachers and students in high-need rural areas to meet workforce demands for more qualified computer science professionals. This project addresses A**bsolute Priorities 1** and **3** by **developing rural teachers' professional capacity to implement CS education,** thereby **creating access** to a rigorous and comprehensive coding and computer science education pathway for rural students**.**

In addition to strong support and commitments from the Governor of California, Gavin Newsom, the current State Superintendent of Public Instruction (SSPI) for California, Tony Thurmond, former State Senator and SSPI, Jack O'Connell, and participating rural County Superintendents, the project has assembled a world-class team of partners including the **University of California Davis** (research team), **TechSmart Inc.** (coding and CS training and curriculum), **Nepris Inc.** (work-based learning)**,** and the **California State University of San Marcos** (Continuing ed. credit for teachers, certificates for teachers and students) (see *Appendix C: Letters of Support*). Evaluation of the project is designed to yield moderate evidence supporting the research-based rationale underlying our innovative approach, and inform subsequent expansion and replication of the Model.

1) <u>National Significance of Proposed Project.</u>

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 agriculture, retail, health information technology, financial services, genomics, medical devices, communications, and clean technology, to name a few. 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 produce 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, as evinced by the fact that **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.

School administrators say the main barriers to offering computer science are a **lack of qualified teachers** and the budget to train teachers (csedu.gallup.com, 2015). 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). Further compounding this issue is a lack of research on how to support in-service teachers with developing the content and pedagogical knowledge to integrate CS across elementary subjects (Yadav, et al., 2018).

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 computer science course offerings. In California, 65% of public high schools offer **no** computer science courses, and availability is lowest within the districts that serve high populations of students of color and low-income students (Kapor Center, 2018). Less than half of surveyed principals and superintendents reported that computer science education was considered important by their school board, yet the majority are forced to de-prioritize computer science in favor of subjects with assessment mandates (csedu.gallup.com, 2015). Among rural principals, 70% reported that they didn't know or disagreed when asked if computer science is a priority in their district (Gallup, 2016).

Recognizing the importance of integrating CS into the K-12 system, the California State Board of Education (SBE) adopted computer science standards on September 6, 2018. However, since it comes with no plan to develop a curriculum framework, local education agencies will need to determine their own curriculum, professional development and implementation needs. Unless these agencies develop a model for student success, the absence of any rigorous, comprehensive pathway approach will likely maintain the status quo: few students pursuing computer science degrees and a continuing 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. These inequities begin in the school system, where only 22% of the AP Computer Science A exam-takers were female, 9% were Hispanic, and 4% were African American (College Board, 2017). The college level had even more pronounced disparities: of the 76,546 computer science degrees awarded in American colleges, only **18% were earned by females, 5% by African Americans, and 3% by Hispanics** (National Center for Education Statistics, 2015). A solution must begin earlier, with a pathway from elementary schools through high schools. Research shows that female students 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).

Many rural communities are in need of employment.

In Rural America, the unemployment rate has hovered around one percentage point higher than the national average over the last 10 years (USDA economic research, 2017). Women in rural areas are employed 3%-7% less than national average dependant upon age (US census Bureau, 2016). Only 22.5% of rural women earn bachelor's degrees compared to 29% of women in urban areas (US health and Human Services, 2011). Poverty in rural areas continues to surpass overall rates in the United States by more than 2% (USDA economic research, 2018). Despite this, research shows that small rural schools can use technology to offer an advanced, varied, and cost-effective curriculum (Hobbs, V. 2004). If rural students can learn career-ready coding and computer science skills from a K-12 pathway, they have the chance to capture some of the million available jobs in the computer science industry and ameliorate the economic disparity in rural areas.

Rural school districts have unique technology needs.

Rural schools face geographic isolation and limited access to university-provided programs, equipment, and resources (Goodpaster et al., 2012), and are less prepared to meet the challenges of 21st century teaching and learning. These barriers also dissuade private industry partners from offering high-quality professional development opportunities. Research is needed to best understand optimal practices and conditions for supporting teachers learning new skills within a rural context (Glover et al. 2016; Vernon-Feagans et al. 2013). A significant part of the nation's students live in these rural districts; for example, 55% of California school districts are considered to be "small school districts" that enroll fewer than 2,500 students per year (Briggs, M. 2018). Project findings will contribute to a much-needed research base about implementing effective CS professional development delivery practices in rural settings.

2) **<u>Development of Promising New Strategy.</u>**

3rd-12th grade Computer Science Implementation Model

This project will develop and implement a promising new evidence-based 3rd-12th grade ***Computer Science Rural Implementation Model*** (*CS-Rural Implementation Model*). All participating districts for this grant are small and rural according to their Locale code. SSDA's *CS-Rural Implementation Model* is an integrated pathway approach that focuses on preparing teachers and creating access for students to learn and apply CS skills across grade levels and subject matter. The Model will include the following five components:

- In-depth CS **teacher professional development** that includes PD for District Office leadership, held at times and locations that meet the needs of Rural districts.
- **Implementation** of a computer science **curriculum pathway** sequence (grades 3-12) containing **differentiated** and rigorous computer science courses.

- **Integration** of core subjects (Math, Science) into computer science in elementary school (grades 3-5).
- Computer science **Competency Certifications** for students and teachers from California State University of San Marcos.
- Computer science **work-based learning program** to connect students and teachers to the world of work.

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

- **Small School Districts Association of California** – The mission of the Small School Districts Association is to provide proactive assistance to small school district governing boards and superintendents through legislative advocacy, collaboration, professional development, and support services.
- **California State University of San Marcos** – Through the leadership of the College of Extended Learning, 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. CSUSM will also host district leadership Bootcamps.
- **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.
- **University of California Davis** – The UC Davis research team will provide research, evaluation, and dissemination support.
- **Nepris** – Industry partner Nepris will connect students to the world of work in computer science, allowing them to find college and career access beyond the geographical divide that often creates a challenge for rural school districts.

In-depth computer science teacher professional development

Many existing strategies for teaching computer science require only that teachers learn how to facilitate student self-paced online computer science tools. However, these approaches do not give teachers the depth, rigor, and support required to actually instruct and assist their students in computer science. Much recent research has supported that a critical feature of high-quality professional development is a focus on content, including how students learn the content and how to meaningfully represent it (e.g. pedagogical content knowledge) (Desimone, 2009; Ingvarson et al., 2005). Research additionally suggests that this approach has the most positive impact on student achievement (Scher & O'Reilly, 2009; Slavin & Lake, 2008).

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). Developing teachers' content and pedagogical skills will be the professional development cornerstones of SSDA's *CS-Rural Implementation Model*.

Teacher professional development will be run by SSDA's industry partner TechSmart, delivered via an in-person cohort model in their Teacher Coding Bootcamps. Bootcamps are taught by TechSmart's master trainers, highly skilled software engineers who have been through teacher-education learning sequences. The Bootcamps are designed to immerse teachers in the full breadth, depth, and rigor of the curriculum their students will experience. Teachers will complete over one hundred coding exercises and write over 2,500 lines of code, then learn the necessary pedagogical approach to teach computer science. They will build skills around the application of computational thinking in the same coding environment that they will use to teach their students. They will also learn how to use TechSmart exercises' differentiation levels during the Bootcamp, practicing how and when to use differentiation through mock teaching sessions during pedagogy training. The objective of the professional development is to provide teachers with a strong computer science competency while increasing their confidence and positive self-perception as a computer science teacher.

Teachers continue to build their knowledge over time by training to teach more advanced classes each year. Elementary teachers will experience 3 levels (CST 10, 20, 30), Middle school educators will experience 2 levels (CST 101, 102), and High School teachers will encounter 2-4 levels (CST 201, 202, 203, 204, 301, or 302).

Facing PD challenges in Rural Settings

Unique challenges plague educators in rural settings, and often inhibit high-fidelity professional development opportunities from supporting them and their communities (Westport, 2002). These challenges include the burden of travel distance and a lack of substitutes to cover for teachers attending PD when classes are in session. To combat these challenges, the *CS-Rural Implementation Model* will offer educators from rural districts options to receive the necessary professional development in multiple convenient ways: Regional trainings will allow teachers to travel a short distance during holiday breaks (Presidents holiday and spring break) or summer (5 or 8 day blocks dependent upon the level).

To build commitment and support model replication and scalability, district leadership will also be offered the opportunity to take part in a “Summer Institute” Bootcamp designed for school leaders. This will allow leadership to learn how to code, teach coding, support teachers, and communicate what is happening in the classroom to the community.

To encourage professional learning continuing beyond the Bootcamp, teachers from rural districts in the Coding Bootcamp cohorts will have opportunities to form a computer science professional learning community (PLC). The goal of PLC meetings will be to support continued learning, collaboration, and the sharing of best practices. Quarterly PLC’s will be held in a virtual setting, facilitated by the TechSmart trainer.

Multi-year computer science curriculum pathway sequence (grades 3-12)

An exposure to computer science is not enough. Schools that offer only stand-alone AP Computer Science and survey courses give students only a single exposure to computer science rather than a meaningful progression of knowledge.

In contrast, SSDA's *CS-Rural Implementation Model* will provide a **comprehensive multi-year computer science curriculum pathway** that will allow students to progress seamlessly through the scope and sequence of material, build 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 noted in the CSTA standards alignment example in found in *Appendix I.* These computer science concepts represent a form of thinking considered to be fundamental for K-12 students because it requires thinking at multiple abstractions (Wing, 2006). Research suggests positive outcomes from the ability to think more systematically (Kafai & Burke, 2013) and the development of mathematical and scientific expertise (Sengupta, et al., 2013). As such, the Next Generation Science Standards (NGSS) include the use of CS as an important practice to develop scientific understanding, and it is one of the eight essential practices recommended by the National Research Council for the scientific and engineering dimension of the Framework for K-12 Science Education (NRC, 2012).

Students progressively learn these 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 languages Python and Java in middle and high school. At the elementary level, a three-year computer science course sequence will be offered from 3rd-5th grade in two 45-minute blocks per week. At the middle school level, three sequential semester computer science courses will be offered on the master schedule, feeding into a four-semester TechSmart computer science course sequence at the high school level.

Differentiated and rigorous computer science courses

Computer science and coding can be challenging, especially as students progress through a sequential pathway of courses. If not scaffolded appropriately, students can become discouraged and give up. The curriculum absolutely must be differentiated, especially for students with special needs and english learners. 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). SSDA's *CS-Rural Implementation Model* will provide teachers and students with a fully differentiated and rigorous curriculum provided by industry partner TechSmart. This curriculum provides **five to six levels of differentiation in each activity**. As easily as pressing a button, teachers can toggle individual students or groups of students to the appropriate level to accommodate their skills (*Appendix I*). To help teachers determine the appropriate level for each student, lessons have clearly defined sets of learning objectives measured through 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 supporting underserved populations of students taking computer science courses. Every course is aligned to national *Computer Science Teachers Association (CSTA)* standards (*Appendix I)*, with learning objectives aligned with Bloom's Taxonomy (*Appendix I)*.

Integration of computer science and coding into other core subjects grades 3-5

Typically, when computer science is offered in schools, it is taught as a stand-alone course. While this is important because it provides dedicated time for building computer science fluency, it doesn't teach students how computer science can be utilized in other content areas and vice versa. To provide these interdisciplinary problem-solving skills, SSDA's *CS-Rural Implementation Model* will supplement its pathway computer science courses with options to integrate computer science into math and science in grades 3-5. This project will leverage industry partner TechSmart's elementary Core Content Pack curriculum for grades 3-5. This curriculum consists of exercises designed to meet specific Common Core and Next Generation Science standards through coding. Examples include a student-coded game about resource management that teaches the difference between renewable and non-renewable resources (social studies), and an interactive landscape-builder that students code and then use to create realistic rock strata for their classmates to investigate (earth science). The Core Content Packs are optional resources for teachers who wish to accelerate their professional learning beyond the pathway courses, and offer students opportunities to utilize another modality of learning for the core subjects.

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 in 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-Rural Implementation Model,* the California State University of San Marcos' School of Extended Learning (in conjunction with the school of computer science), will **develop 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 a certificate for completion of the Skylark (elementary), Python (middle/high school), and Java (high school) pathways. These certifications will be designed to ensure that certified students are proficient in Skylark, Python, or Java, and that they have demonstrated mastery over the relevant CSTA standards.

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

SSDA's industry partner Nepris will virtually connect industry experts live into the classroom, to show and tell how specific curriculum topics can be practically applied in the workforce. This approach provides an effective way for companies and professionals within industry to extend education outreach and create equity of access (Fisher, J., 2018). Teachers will also invite subject matter experts to help students with their coding projects and provide timely feedback, as well as having students virtually present their capstone projects to a panel of industry experts. Students will interview and interact with professionals with specific job skills so they can make the right choices when it comes to college and careers within the computer science realm. Since rural schools simply can't afford for students to go on field trips every week, and most teachers do not have access to professionals around the world (Buffington, P., 2017), the SSDA's *CS-Rural Implementation Model* instead brings the workplace into the classroom.

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

Exceptional Approach to Absolute Priority 1
(Demonstrates Rationale)

SSDA's *CS-Rural 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-Rural Implementation Model* developed in this project can be replicated in other rural school districts throughout the country. The evaluation will utilize data to determine the best way to offer CS professional development, as well as inform progress on the other goals, objectives, and outcomes.

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.

Table 1: Research findings in support of SSDA's *CS-Rural Implementation Model*

***CS- Implementation Model* component**	**Research Findings**
1. In-depth computer science teacher professional development.	School administrators citing 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). Rural schools frequently are defined by isolation, long distances between places, and their sparse populations. These characteristics affect the cost of transportation, access to goods and services, the ability to recruit and retain teachers, the level of parental participation, the number and level of student participation in extracurricular activities, and the proximity to entertainment, services, shopping, and other amenities that people in other communities take for granted. (Westport, C. 2012)
2. Multi-year computer science curriculum pathway sequence (grades 3-12) containing differentiated and rigorous computer science courses on the master schedule.	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)
3. Integration of **core subjects** (Math, Science) in elementary school grades 3-5 into computer science.	Understanding of computational concepts through an active approach, Project Based Learning, usefulness, motivation, and commitment underline the importance and effectiveness of implementing a Visual Programming Language from active methodologies in primary education across the curriculum. (Lopez, et al., 2016)
4. 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 counterpart. Therefore employers often offer a monetary premium to attract certified professionals. (Cegielski, Rebman, and Reithel, 2003) Companies like Apple and Google have gotten rid of the requirement to hold a Bachelor's degree to work for them as a

	programmer. (Connley, C. 2018)
5. Computer science **work-based learning** program to connect students and teachers to the world of work via partnership with Nepris.	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 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 rural schools to ensure that it creates a high likelihood to improve student outcomes in computer science, as well as improving outcomes in the core subjects of math and science in grades 3-5 via integration of computer science into those subjects. Findings will also create potential for further research and development of coding and computer science centered courses integrated into other core curricular areas in secondary schools.

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-Rural Implementation Model* as a field-initiated innovation in grades 3-12 in 54 districts across 9 counties in rural Northern California. It will impact 69 schools, 265 teachers, and approximately 8,168 students. 52% of the students impacted in this study receive free and reduced meals (CDE, 2017), highlighting the need for underserved students to receive this opportunity.

The evaluation design will capture the impact of the Model with developing capacity to implement a rigorous CS pathway in a rural educational context and provide on-going formative feedback about model implementation during each phase. The project will lead to improved student achievement and outcomes in computer science in grades 3-12, as well as in math and science. It will be delivered through an innovative public and private partnership between the SSDA, higher education, 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 in Rural schools with a rigorous comprehensive computer science pathway from 3rd-12th 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 challenge of teachers in rural school districts not having computer science education 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 as described on pg 7. The next step will be to provide students with a **comprehensive multi-year computer science curriculum pathway (GOAL 2)** that will allow students to gain a depth of knowledge in computer science and coding skills. To provide students with interdisciplinary problem-solving skills, SSDA's *CS-Rural Implementation Model* will supplement these computer science courses by **integrating Math and Science exercises and activities into Computer Science curriculum via core content packs (GOAL 3).**

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 4)** 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 5)** for students, in which they will remotely interact live with professionals in computer science related fields.

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

TABLE 2: Goals, Objectives and Outcomes		
Goals	**Objectives**	**Outcomes**
1.Establish in-depth teacher professional development in computer science (CS), coding and computer science pedagogy for elementary, middle and high school teachers as well as District Leadership.	1A: Increase the number of teachers teaching computer science within each district to 38%. 1B. Build teacher's proficiency in computer science concepts and writing computer code (coding). 1C. Build District Leaderships proficiency in computer science concepts and writing computer code (coding), and ability to support teachers who teach computer science. 1D. Build teacher's proficiency in computer science pedagogy and instruction. 1E. Increase teacher's positive self-perception of themselves as a computer science teacher.	1A:1 The number of teachers successfully completing computer science teacher professional development will be: 100 elementary school teachers 80 middle school teachers 35 high school teachers 1B:1 All participating teachers will score 75% or greater on each end of unit summative assessment in the CS professional development course. 1B:2 90% of participating teachers will successfully complete the hands-on final coding project in the computer science professional development course. 1C:1 60% of Participating districts will send at least 1 District Leader to the Leadership Bootcamp. 1C:2 80% of District Leadership who attended Bootcamps will demonstrate a greater awareness of CS education, and how to support a pathway approach in their district. 1D:1 90% of teachers will score above 75 % on the computer science pedagogy rubric during their mock teaching practical. (Appendix I) 1E:1 90% of teachers teaching computer science will score 90% on a qualitative teacher self-perception survey.
2. Implement an engaging multi-year computer science & coding curriculum pathway on the master schedule available to all students in 3rd - 12th grade students at participating schools.	2A: Each elementary school will provide four full-year computer science courses. Each middle school will provide three semester computer science courses. Each high school will provide four semester computer science courses. 2B. Increase 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 high needs students (Low socioeconomic/students who receive free and reduced meals) taking	2A:1 The percentage of students completing computer science courses in the districts will be: 54% of elementary school students 26% of middle school students 10% of high 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% (positive experience) on a qualitative student satisfaction survey. 2D:1 The number of high-need students successfully completing computer science courses will increase by 70%.

	computer science courses. 2E. Increase student achievement in math and science.	2E. Increase student achievement by 5 % in math and science, as measured by standardized assessments.
3. Integrate, Math and Science exercises and activities into Computer Science curriculum via core content packs for grades 3-5. *Core Content Packs are optional for teachers in grades 3-5 (Appendix I)	3A. Students apply computer science concepts and coding skills as a tool to learning math and science.	3A: 70% of students in participating classes will complete three coding exercises in math and science in grades 3-5.
4. Provide 3rd-12th grade students and teachers who complete CS courses with Computer Science Competency Certifications from the California State University of San Marcos.	4A: Develop a Computer Science Competency Certification for each computer science course in the pathway progression in partnership with the California State University of San Marcos School of Extended Learning. 4B: Issue a Computer Science Competency Certificate to students and teachers who successfully complete a computer science course in the curriculum pathway progression.	4A:1 The number of Computer Science Competency Certifications developed will be: 3 elementary school certificates 2 middle school certificates 4 high school certificates 1 Elementary certificate for full completion 1 Middle school certificate for full completion 1 High school certificate for full completion 4B:1 80% of participating students will earn one Computer Science Competency Certificate during the first year. 4B:2 50% of participating students will earn four (or more) Computer Science Competency Certificates over the 5 year grant period. 4B:3 20% of participating teachers will earn two (or more) Computer Science Competency Certificates over the 5 year grant period.
5. Create a computer science work-based learning program to connect 3rd-12th grade students and teachers to the world of work via Industry partners.	5A: Provide students with work-based computer science opportunities and experiences through virtual means, connecting students with world wide access to CS industry professionals. 5B: Utilize specific in-classroom work-based computer science activities that are relevant, real-world examples of tasks that professionals perform.	5A:1 The percentage of participating students completing work-based computer science learning opportunities will be: 70% of elementary school students will participate in virtual company visits. 80% of participating middle school students participating in virtual industry chats/company visits. 5B:1 Five in-classroom work-based computer science activities will be utilized for each course on the curriculum pathway.

	5C: Develop or fuel existing interests in studying computer science post secondary and/or pursuing a computer science related career (middle and high school students).	5C: Each year 50 % of participating 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 provides 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 track and report these interim implementation outcomes on an annual basis. These data will allow the research team to evaluate change over time to assess the impact of the model after five years.

2) Model of Performance Feedback & Improvement

The *CS-Rural Implementation Model* will begin with a pilot consisting of 19schools, with the objective of learning, measuring, gathering feedback, and revising the plan prior to scaling the implementation to a larger number of counties, districts, and schools. The project will then be implemented incrementally based upon a three phased roll-out (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.

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 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, 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) Adequacy of Resources and Quality of Management Plan

1) Management Plan: Timelines, Milestones and Responsibilities

The project is organized into four 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 tasks, timelines, and milestones for the next year based on feedback.

Planning Phase

During the Planning Phase of the project, an implementation plan identifying schools, grade levels and teachers by phase will be created. Matching and selection of treatment and controls will then be conducted. The plan will be reviewed with district leadership and school administrators throughout the Rural Counties and School Districts partnering with SSDA. Upon approval, detailed planning for the Pilot phase will occur, including: organizing teachers into professional development (PD) cohorts, identifying PD dates and locations, and finalizing the integration of the computer science classes into the elementary school day and middle/high school master schedules. Nepris 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 California Davis will finalize the evaluation plan.

Pilot Phase

The Pilot Phase will begin implementation in three counties in Northern California: Siskiyou, Lassen, and Modoc. The Pilot phase will affect 15 rural school districts and will reach 45 teachers and approximately 1,580 rural students. The goal of this phase will be to field test the *CS-Rural 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 counties, districts, and schools. During this phase, the first cohort of teachers will complete the Teacher Coding Bootcamps, which will be held in multiple ways in order to meet the unique needs of rural schools and teachers. The teachers will earn their first Computer Science Competency Certification upon completion of this first Bootcamp. The first courses of the computer science pathway will be taught: CS10 (Intro to Skylark) in elementary school, CS101 (Introduction to Python) in middle school and CS 201 (Introduction to Python) in high school. Students successfully completing these courses will earn the corresponding CS Competency Certification. Optional Core Content Packs will be offered in the elementary school grades 3-5, and the initial industry work-based learning activities will be delivered. 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, middle, and high schools, expanding the pathway. More schools will be included, and teachers will attend additional Coding Bootcamp PD that correspond to these courses. At the completion of each phase, evaluation data will be collected, the results of the pilot will be evaluated, and an Annual Formative Evaluation Report will be completed. Lessons learned will be utilized to revise the implementation plan for the next phase.

The Annual Evaluation Report will be completed during each Expansion Phase with the Impact Evaluation Report completed after the Expansion Phase 3. Table 3 includes details about each expansion phase.

<u>LEGEND</u>:
ES: Elementary Schools, MS: Middle Schools, HS: High Schools
SSDA: Small School Districts Association, TS: TechSmart, CSUSM: Cal. State University San Marcos

TABLE 3: Timeline, Milestones and Responsibilities		
PLANNING: Award Earned - October 2020		
MILESTONE	**County/District/School**	**RESPONSIBILITY**
Identify by phase, which schools, grade levels and teachers	None	SSDA, TS
Approval: Implementation Plan		SSDA
Teacher Cohorts formed - ES, MS and HS		SSDA, TS
Teacher Professional Development dates established		SSDA, TS
MS and HS CS course place on master schedule finalized		SSDA, TS
Deliver: Operational WBL plan for ES, MS and HS		Nepris
Deliver: CS Competency Certificates		CSUSM
Deliver: Process for issuing Certificates		CSUSM
Deliver: Final Evaluation Design Plan		UC Davis
PILOT PHASE: June 2020 - June 2021		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot ES, MS, HS school teachers	<u>Counties (3):</u> Siskiyou, Lassen, and Modoc <u>Pilot Districts (15):</u> Bogus, Delphic, Dunsmuir, Dunsmuir HSD, Hornbrooke, Scott Valley, Scot Valley HSD, Tulelake, Modoc Joint	TS
Competency Certificates issued for CS10, CS101, CS 201		CSUSM
ES: CS10 course taught & Core Content Packs utilized		SSDA, TS
MS: CS101 course taught		SSDA, TS
HS: CS201 course taught		SSDA, TS
Deliver: documented lesson learned from Pilot schools		SSDA, TS, UC Davis
Deliver: modified implementation plan for Expansion Phase 1		SSDA, TS

Students complete Work-based Learning (WBL) Activities	Unified, Surprise Valley Joint Unified, Lassen, Richmond, Big Valley, Westwood, Fort Sage <u>Schools (19):</u> 3-12 <u>Teachers (45)</u> ES: 18 teachers MS: 14 teachers HS: 13 teachers <u>Students (approx.)</u> ES: 450 students MS: 350 students HS: 780 students Total: 1,580 Econ dis. avg: 65%	Nepris
Deliver: Annual Formative Evaluation Report		UC Davis
EXPANSION PHASE 1 : July 2021 - June 2022		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot and Phase 1 teachers	<u>Counties (2):</u> Plumas, Shasta <u>Districts (12):</u> Columbia, Junction, North Cow Creek, Anderson, Pacheco, Bella Vista, Happy Valley, Shasta Union, Black Butte, Millville, Fall River, Plumas. <u>Schools (17)</u>: 3-12 <u>Teachers (79)</u> ES: 30 teachers MS: 35 teachers HS: 14 teachers <u>Students (approx)</u> ES: 750 students MS: 875 students HSL: 840 students Total Students: 2,465 Econ dis. avg: 55 %	TS
Competency Certificates issued: CS10, CS20, CS101, CS102.		CSUSM
ES: CS10,CS20 courses taught		SSDA, TS
MS: CS101, CS102 courses taught		SSDA, TS
HS: CS101, CS102 courses taught		SSDA, TS
ES: Core Content Packs taught in grades 3-5		SSDA, TS
Deliver: Documented lesson learned from Expansion Phase 1		SSDA, TS, UC Davis
Deliver: Modified implementation plan for Expansion Phase 2		SSDA, TS
Students complete CS Work-based Learning (WBL) Activities		Nepris
HS students complete job shadows and internships		Nepris
Deliver: Annual Formative Evaluation Report		UC Davis
EXPANSION PHASE 2 : July 2022 - June 2023		

MILESTONE	SCHOOL CLUSTER	RESPONSIBILITY
Teachers trained: Pilot, Phase 1 and Phase 2 teachers	Counties (2): Trinity, Sonoma Districts (9): Basin, Trinity Alps, Mountain Valley, Burnt Ranch, Old Adobe, Cotati-Rohnert, Twin Hills, Petaluma, Oak Grove Schools (10): 3-12 Teachers (43) ES: 22 teachers MS: 16 teachers HS: 5 teachers Students (approx) ES: 550 students MS: 400 students HSL: 300 students Total Students: 1,250 Econ dis. avg: 45%	TS
ES Competency Certificates issued: CS10, CS20 and CS30		CSUSM, TS
MS/HS Competency Certificates issued: CS101,CS102,CS103		CSUSM, TS
ES: CS10, CS20 courses taught		SSDA
MS/HS: CS101, CS102 courses taught		SSDA
MS: Math & Science w/coding courses taught		SSDA
HS: CS101, CS102, CS103 courses taught		SSDA
Students complete CS Work-based Learning (WBL) Activities		SSDA, TS, UC Davis
HS students complete virtual job shadows and internships		SSDA, Nepris
Deliver: Documented lesson learned from Expansion Ph-2		SSDA, TS
Deliver: Modified implementation plan for Expansion Ph-3		UC Davis
Deliver: Annual Formative Report		US Davis
EXPANSION PHASE 3 : July 2023 - June 2024		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot, Phase 1, Phase 2 and Phase 3 teachers	Counties (2): Sutter, Kern Districts (14): Rio Bravo, El Tajon, Lakeside, Maple, Pond, McKittrick, Maricopa, Buttonwillow, Sierra Sands, Pleasant Grove, East Nicolaus, Marcum-Illinois, Browns, Nuestro Schools (23): 3-12 Teachers (92) ES: 56 teachers MS: 30 teachers HS: 12 teachers	TS
ES Competency Certificates issued: CS10,CS20, CS30		CSUSM
MS/HS Competency Certificates issued:CS101,CS102,CS103 and CS104		CSUSM
ES: CS10, CS20, CS30, courses taught		SSDA, TS
MS: CS101, CS102 courses delivered		SSDA, TS
HS: CS101, CS102, CS103, CS104 courses delivered		SSDA, TS
Students complete CS Work-based Learning (WBL) Activities		Nepris
HS students complete virtual job shadows and internships		Nepris
Deliver: documented lesson learned from Expansion Ph-2		Nepris
Deliver: Impact Evaluation Report		US Davis

	<u>Students (approx)</u> ES: 1,400 students MS: 750 students HS: 720 students Total Students: 2,870 Econ dis. avg: 41% **<u>Total Impact:</u>** **Total Counties: 9** **Total Districts: 54** **Total Schools: 69** **Total Teachers: 265** **Total Students: 8,168**	

2) <u>Key Staff and Partners</u>

SSDA has assembled a world-class team of industry and higher education 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 technology integration into education matches them perfectly with this initiative.

Higher education partner the **University of California Davis** is ranked 38th best school in the nation by US News and World Report. This team will conduct and lead our research efforts to determine the efficacy of SSDA's *CS-Rural Implementation Model*. Taking the lead will be Dr. Joanne Bookmyer, Senior Director of Inquiry and Improvement Science, at the UC Davis, School of Education, REEd Center.

Industry partner **TechSmart** has extensive experience implementing computer science at school districts across the country. Over the last eight years, they have developed and delivered rigorous, comprehensive computer science courses via their platform, along with training and supporting thousands of teachers who have taught tens of thousands of students nationwide.

Industry partner **Nepris** arms educators with a technology platform to bridge the gap between industry and education. Nepris has reached over 50,000 teachers connecting nearly 400,000 students with thousands of industry professionals bringing real world learning to every student. 55% of students reached were from underserved communities.

TABLE 4: Key Staff and Partners	
Name/Organization	**Biography**
Debra Pearson *Executive Director* ***Small School Districts Association of California***	Debra Pearson is currently the Executive Director for the Small School Districts' Association (SSDA). She has held this position for over six years and also served on SSDA's Executive Committee for 20+ years. Ms. Pearson has over 30 years in education as a secondary and middle school teacher, Title 1 Teacher, Principal, Superintendent/Principal, and Superintendent. Her administrative experience ranges from the primary grades through high school. Additionally, she currently serves on the Implementation Committee for the Office of Public School Construction. Ms. Pearson is the past president of the California Association of Federally Impacted Schools. Her awards and recognitions include Teacher of the Year, ACSA Region 2 Superintendent/Principal of the Year, and ACSA Region 2 Superintendent of the Year. She is a graduate of CSUC with a BA in Liberal Studies and an MA in Education Administration.
Corrie Pelc Membership and Marketing Director ***Small School Districts Association of California***	Corrie Pelc is currently the membership and marketing manager for the Small School Districts' Association (SSDA). She has over 20 years of writing and editing experience as a magazine editor, freelance writer, and blogger. And she has more than 11 years of experience in association and nonprofit management and communications.
Corey Bess M.Ed. *Director of Operations* ***TechSmart Inc.***	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 San Diego California. 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 for the districts he worked in. Corey will serve as the liaison between TechSmart and SSDA. Corey oversees curriculum development, training operations and professional development, as well as general operations for TechSmart.
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 trainied 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.
Stephanie Mao M.A. *Lead Trainer*	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

TechSmart Inc.	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.
Kyla Fury 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.
Mike Sennott M.FA. *Creative Director* ***TechSmart***	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 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.

Sabari Raja M.A. Co-Founder & CEO ***Nepris, Inc***	Sabari is the co-founder of fast growing edtech company, Nepris Inc (www.nepris.com), a first of its kind cloud-based platform connecting industry and education to inspire learners through real world connections and career exposure. She has worked in education technology for 18 years leading product and content strategy, business development, publisher relations, and emerging market growth strategies. She is passionate about working with educators to translate their needs into scalable technology solutions. She is on the board of Friends of Texas Public schools (FOTPS), the business advisory board at Texas Education Agency(TEA) and on the Champions board of Texas Girls Collaborative and has a special interest in engaging girls and minorities in STEM. She also speaks on the topic of entrepreneurship and education technology at such venues as SXSWEdu, TEDx, Smartbrief and TCEA. Sabari has an undergraduate degree in Electrical Engineering from India, Masters in Computer Science from Louisiana State University and an Executive MBA from Cox School of Business, SMU. She lives in Austin, Texas and is also a busy mom with 2 boys in middle school.
Thomas McMullen M. Ed. Regional Sales Director, ***Nepris, Inc***	Thomas brings 20 years of exceptional experience as both an educator and an educational sales consultant. As a past educator for the Los Angeles Unified School District, Thomas has a passion for improving the lives of students who struggle with math and literacy, and partnered to implement instructional solutions that met targeted student populations such as regular educational instruction, English Language Learners and special needs. Thomas enjoys working with all students and he excels in the recognition of student learning outcomes. Always attuned to best practices and research-based solutions for students, Thomas genuinely enjoys helping educators find the most appropriate programs for their student needs. Thomas is an avid camper and can usually be found at a local park on the weekends either practicing soccer with his children or watching one of their matches. Thomas holds his Bachelors in Humanities from U.C. Irvine and his Masters in Early Childhood Education from Pepperdine University.
County Superintendents: ***Sutter, Plumas, Siskiyou, Kern, Shasta, Lassen, Modoc, Trinity, and Sonoma***	Please see letters of support (Appendix C) from the following County Superintendents: *Sutter County:* Tom Reusser, *Plumas County:* Terri Oestreich, *Modoc County:* Mike Martin, *Trinity County*: Susan Supahan, *Siskiyou County*: Kermith Walter, *Lassen County*: Patricia Gunderson *Sonoma County*: Dr. Steven Herrington *Kern County*: Dr. Mary Barlow, *Shasta County*: Judy Flores.
Dr. Joanne Bookmyer, Ph.D. *Senior Director of Inquiry and Improvement Science* ***University of California Davis School of Education***	The UC Davis evaluation team has led rigorous efficacy studies of professional development and curriculum interventions, which include large-scale experimental studies funded by the U.S. Department of Education's Institute of Education Sciences (IES) and the National Science Foundation (NSF). Joanne Bookmyer is Senior Director of Inquiry and Improvement Science at the REEd Center and will manage the evaluation team. Her research focuses on the organizational complexities of creating and maintaining teacher-driven professional growth systems. The REEd Center, at the UC Davis School of Education, works collaboratively with local education agencies to build capacity

	to implement and continuously improve upon teacher professional growth systems.

3) Sustainability

SSDA's *CS-Rural Implementation Model* will build the framework within districts to support comprehensive coding and computer science education. Teachers at scale will have received the necessary professional development and training to sustain CS education in their schools, districts, and counties. Please refer to the letters of support for more information regarding the continued support of this project after federal funding ends.

D. Project Evaluation

D1. Meeting What Works Clearinghouse (WWC) Group Design Standards

UC Davis will conduct a multi-year formative and impact evaluation of the project that meets What Works Clearinghouse (WWC) Group Design with Reservations. At present, a quasi-experimental design (QED) that utilizes a non-random, matched comparison group is proposed for the impact evaluation. Given the variation in district/school type configurations in rural areas, the feasibility of utilizing an experimental random assignment design will need to be further discussed once the population of study participants has been confirmed.

The study will include approximately 69 schools, 265 teachers, and 8,168 students across grades 3-12, over 54 districts in 9 counties, over a five year period. To maximize the comparability of the intervention and the comparison groups, Mahalanobis distance (Rubin, 1980) will be used to create matched school samples based on key covariates, such as prior year's math and science standardized achievement scores (pre-intervention measures). To reduce the threat of confounding variables, additional district administrative demographic data of teacher and student characteristics (e.g., school size, proportion of English language learners and socio-economically disadvantaged students, and years teaching) will also be used as matching covariates to ensure treatment and comparison groups are statistically equivalent in every way possible. If the standardized difference in means between the two groups exceeds the ≤0.25 WWC baseline equivalence threshold, statistical adjustments, such as regression-based covariate adjustment, will be conducted to restore baseline equivalence or the matching process will be further refined until covariates are balanced. We will finalize the matching approach post-recruitment and prior to assignment. We expect findings from this study to be generalizable to similar districts.

D1.1. Power Analysis. The study design will be sufficiently powered to minimally detect a modest to moderate effect size for main effects analysis, based on standardized mean differences between groups on outcome measures. To ensure a reasonably good chance of detecting a true intervention effect and reduce probability of Type 1 error, both alpha and power will set by standard convention, .05 for a two-tailed test and target power at 80%, respectively, (Cohen, 1988). MDES will be established once the sample is finalized. WWC guidelines for reporting effect sizes and determining statistical significance will be adhered to and any necessary corrections for multiple comparisons will be conducted.

D1.2. Impact analysis and outcome eligibility. The primary impact and implementation research questions this evaluation will assess are:

Impact Research Questions:

1. What is the impact of the CS-Rural Implementation Model on (a) student achievement in mathematics and science, and (b) CS skills and confidence in CS?
2. What is the impact of the Model on treatment teachers' (a) CS content knowledge and pedagogical practice, and (b) confidence in teaching CS?

Implementation Research Questions:

3. To what extent are Model components implemented by treatment teachers, and what is the mediating effect of implementation factors on student outcomes?

4. To what extent is the curriculum component differentiated and what is the mediating effect on student outcomes?

The impact questions will allow us to determine how well the model prepares teachers to teach CS effectively and make causal inferences about the impact of the Model on student outcomes in treatment classrooms relative to comparison classrooms. The implementation questions will not only provide program developers and LEA partners with formative data on interim outcomes to inform continuous improvement, but are essential to providing context and confidence in evaluation findings by examining links between the extent to which an intervention is implemented and actual intervention effects (Freeman, et al., 2016; O'Donnell, 2008). These fidelity data will also assist with determining implementation threshold effects and which components are critical for achieving and maintaining intervention effectiveness (Abry, et al., 2015; Durlack & DuPre, 2008).

From an internal validity perspective, the unit of analysis should be equivalent to the number of independent replications of the intervention (Shadish, et al., 2002). As the intervention is provided to and delivered by teachers in a classroom setting, the teacher/classroom will be the unit of analysis. To appropriately address the hierarchical nature of the study data (students nested within classrooms), 2-level hierarchical linear modelling (HLM) will be used to estimate the impact of the Model on student outcomes. An additional model will include only the treatment sample in order to assess the impact of mediating (implementation) variables on student and teacher CS outcomes. All HLM models will control for pre-assessment scores and demographic covariates. Impact of the Model on the professional development of treatment teachers (RQ2) will be assessed using a paired sample t-tests to determine whether there were statistically significant mean differences between a teacher's first course and final course assessment score, pedagogical rubric score, and confidence self-survey score as they progress through the pathway learning sequence.

D2. Effective strategies suitable for replication in other settings

Fidelity of implementation will be assessed within the context of our impact evaluation (D1.2), which will improve statistical power in treatment findings by explaining variance in outcomes, but will also be assessed formatively to improve external validity by testing and outlining effective conditions and strategies for replicating the *CS-Rural Implementation Model*. During the planning year, a fidelity matrix will be created from the logic model and Table 2 to ensure that key components, indicators, measures, and criteria are carefully tracked at each relevant level (school, teacher, and student) by the project and evaluation team. The fidelity matrix will also guide the data administration/collection activities for each phase. During this time, all relevant data sources and instruments will be identified and finalized in the planning year, including availability of comparison group practice measures, as CS is not widely offered in many of the participating rural districts, and development of a composite fidelity measure. Fidelity of implementation data collection begins in the pilot phase and will provide on-going, formative information about implementation of model components and interim outcome measures. In phases 2 and 3, our formative evaluation will include interviews with a sample of participating teachers, principals, and superintendents to explore and better understand facilitating factors and barriers around model implementation that may be unique to creating sustainable access to CS education in a rural setting.

D3. Valid and reliable performance data on relevant outcomes

While computer science education remains an emerging imperative in K-12, what foundational competencies are measured (e.g., computational thinking, problem-solving, etc.) lacks consensus, and how they are measured varies in approach (de Araujo, 2016; Denning, 2017; Kalelioğlu, 2018). As example, existing research on computational thinking (CT), a common thread in CS, has largely focused on definitional concepts, environments, and tools and curricula to develop these skills (Grover & Pea, 2013). Yet, there is a lack of valid and reliable scales and measurement tools specific to measuring CT (Illic, et al., 2018). As a result, the available measures are typically aligned to or are embedded within CS curricula, or employ cognitive methods such as self-efficacy or confidence surveys. Moreover, the research-base on how best to prepare in-service teachers with the content and pedagogical knowledge needed to teach CT remains limited (Yadav et al., 2018; Hsu et al., 2018). Descriptions of measures used to evaluate primary outcomes in this study are described below.

D3.1 Impact Measures. Academic achievement outcomes will be measured using Smarter Balanced Mathematics and California Science Test (CAST) standardized assessment scaled scores and domain level performance. The Smarter Balanced and CAST assessments are validated and meet WWC outcome eligibility and reporting requirements. Computer science skills and confidence outcomes will be measured by a validated instrument, such as the Computational Thinking Scale (Korkmaz, et al., 2015) or the Computational Thinking Test (CTt) developed by Gonzalez (2017). Both instruments have reliability estimates >.70. The selected measure will be administered to both the treatment and comparison groups at baseline and end-of-year.

Within-treatment group (teacher and student) computer science skill outcomes will be measured using the TechSmart's course embedded and hands-on assessments, which are evidence-centered assessments. The platform courses are CSTA aligned, demonstrate face validity and are not judged to be overaligned by WWC standards. In addition, calibrated trainers conduct an observation of each teacher's mock teaching practical during PD Bootcamps using a CS Pedagogical Observation Rubric. The rubric was designed by TechSmart curriculum designers and assesses three pedagogical elements, *Use of Platform Tools, Instructional Content and Explanation, and Student Interaction and Engagement*, on a four point scale, across three dimensions *Instructional Lesson*, *Coding Technique*, and *Exercise*. The teacher end of course assessment and observation rubric are administered at the end of each Bootcamp. Reliability estimates will computed for the rubric in the pilot phase.

D3.2 Interim Measures. Implementation data will be collected from a number of data sources such as CS platform system metadata (e.g., components/levels/resources accessed, assessment scores, lessons completed, etc.), site-based tracking logs (work-based learning opportunities, certificates, PLCs, etc.) and interviews to track interim outcome/implementation measures as outlined in Table 2.

D4. Clearly articulated key components, mediators, and outcomes

Program components, outcomes, and formative and impact evaluation objectives were thoroughly discussed in previous sections. Over the grant period, the multiple sources of data collected on each component will not only allow us to assess main effects but will also support a rich line of exploratory analysis to adequately investigate mediating and moderating implementation factors within rural contexts and at multiple levels (teacher, student, school).