UCLA STEM+C^3

Preparing and Sustaining the Next Generation of Effective STEM Educators for Urban Schools

Teacher Quality Partnership (TQP) Grant Program

Proposal Submitted to the US Department of Education

Office of Elementary and Secondary Education

May 20, 2019

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The **UCLA STEM+C^3 Teacher Residency (UCLA STEM+C^3)** builds on the wealth of knowledge and experience gained from the successful design and implementation of the UCLA IMPACT Urban Teacher Residency Program, which successfully prepared 255 highly effective math and science teachers for high needs schools in Los Angeles. The thoughtful integration of three critical C's: 1) **C**omputational Thinking Practices 2) **C**omputer Science Principles and 3) **C**ommunity of Practice (therefore noted C^3) into IMPACT's robust and effective STEM teacher residency program will create a sustainable and systemic approach to developing a community of STEM teachers who understand and leverage computational thinking and computer science principles into their practice, foundational components of today's classroom. Through a collaborative partnership between **UCLA Center X, the Centinela Valley Union High School District** (CVUHSD)**, and the Alliance for California Computing Education for Students** (ACCESS), we propose a re-imagined and enhanced 16-month program leading to a California Preliminary Teaching Credential (in Math or Science), Computer Science Supplemental Authorization and Masters in Education. STEM+C^3 will serve 48 pre-service teachers (16 each year) and approximately 16 – 20 in-service STEM and Computer Science teachers -- ultimately transforming STEM learning for an estimated 8,000 – 27,000 students over the life of the grant, and thousands more in the future. STEM+C^3 presents an exceptional approach to **Absolute Priority 1: Partnerships for the Establishment of Effective Teacher Residency Programs** and **Competitive Preference Priority 1**: **Promoting STEM Education with a particular focus on Computer Science** (as described in Part I Project Design).

Over twenty-five years ago, UCLA's Center X challenged the status quo of teacher preparation by establishing an innovative, experimental program that has since recruited thousands of diverse, high-achieving, aspiring teachers and prepared them to teach and remain in

the hardest to staff urban schools in Los Angeles. Over the past *10 years*, this experiment deepened with the launching and enhanced implementation of UCLA IMPACT, an innovative urban teacher residency program. Supported by 2009 and 2014 Teacher Quality Partnership grants, IMPACT successfully prepared 255 math, science, elementary and early childhood educators (seven cohorts) within a consortium of high-need schools, supported by exceptional mentor teachers to: (1) improve college and career readiness of traditionally underserved students; (2) respond to the local need and national call to recruit, prepare, and retain highly-effective STEM teachers from diverse backgrounds through preparation and sustained professional learning; (3) advance school and district-level Computer Science and STEM reforms with a particular focus on novice and mentor learning; (4) deepen STEM partnerships, between IHE and LEA, to support teacher learning (preparation through induction) and student achievement, (5) promote continuing innovation in teacher preparation and program sustainability; (6) contribute to the research base on STEM teacher preparation, and STEM teacher residencies in particular

The final cohort of IMPACT novice teachers completed their STEM residency program in June 2018. To date, IMPACT successes have directly addressed key challenges to access, equity, and student learning in high-need schools, including:

● ***STEM Teacher Shortage***: 195 novice teachers were recruited, prepared, and licensed to teach STEM in high-need K-12 schools, including customized induction co-designed and implemented by the IHE-LEA partners

● ***STEM Teacher Diversity Gap***: 137 teachers of color attained preliminary licensure in STEM fields

● ***Teacher Retention***: 88% (127 out of 144) of IMPACT-prepared STEM teachers retained in high-need schools after three years

● ***Mentor Teacher Quality***: 151 K-12 STEM mentors/lead teachers engaged in sustained, advanced STEM professional development, including ten who attained administrative services credentials and a master's degree through the Principal Leadership Institute at UCLA

● ***High Leverage Teaching***: Sustained learning and implementation of key high-leverage dimensions of practice by novice and accomplished teachers, including content rigor, academic discourse, equitable pedagogy, and classroom ecology.

IMPACT successes and lessons learned directly support the goals and project design of UCLA STEM+C^3, a new residency that builds upon the best guiding principles of IMPACT while responding to the unique, local context of our new partnership. In addition, Center X has developed, implemented and studied two NSF-funded curricula and professional development programs that will be used as building blocks for the re-designed teacher preparation curricula: The *Exploring Computer Science (ECS)* course has increased access for traditionally underrepresented students to Computer Science and is now a national program taught in more than 34 states, and the trail-blazing *Introduction to Data Science (IDS)* curriculum and professional development program that integrates computational thinking, statistical thinking, and mathematics to ensure all participating students are exposed to computational thinking, an essential and critical skill for success in math, science and beyond.

The shifting landscape of education towards computational thinking (CT) and computer science (CS) requires teacher preparation programs to respond by redesigning curriculum, clinical experiences, and mentor development supports. Recent findings from ECS and IDS evaluation reports (Ong, Dockterman, Griffin, Hansen & La Torrre Matrundola, 2015; Gould,

Machado, Molyneux, Johnson, & Trusela, 2018) indicate ECS and IDS as powerful resources, that this project will leverage, to improve STEM teacher preparation and development:

● ***Growth of Self-Reported CS Knowledge*:** ECS Learners reported dramatic increases in knowledge across all domains that were measured (i.e., the major units of ECS curriculum).

● ***Growth of Interest in CS***: Significant growth in interest in computer science, particularly large among ECS Latino Americans students, females, and students who reported speaking a language other than English at home.

● ***Alternative Mathematics Pathway:*** IDS is a successful alternative mathematics pathway to college: 68% took IDS to satisfy a 4th-year mathematics requirement; 32% took IDS to satisfy Algebra II requirement.

● ***Improvement in Content Knowledge:*** IDS students experienced an average of 10% percentage point improvement in conceptual understanding of statistics (statistically significant) among IDS students). Most of this increase was in the Analyze Data domain, the most computationally intense domain. Teachers saw an overall increase in 7 percentage points on the same instrument through professional development.

It is also important to note that through the intensive, iterative cycle of research and development, UCLA Center X has sifted through the complexities of CT and CS in order to put forth a clear working definition and rationale for the consideration of CT and CS into the K-12 curriculum: *Integrating CT and CS practices and tools presents a contemporary approach to learning math and science, an approach that is much more relevant to the data-rich and technology-driven context of today. STEM subjects provide a context in which CT and CS Principles can be applied to solve problems.* Both teachers and students have indicated

increased engagement because of the alignment to "real-world" problem solving CT and CS creates in the classroom.

Center X's demonstrated experience in developing and implementing an innovative urban teacher residency program that recruits, prepares, produces, and retains diverse, highly qualified and effective STEM teachers for and in high-need schools, as well as our decade-plus commitment to broadening participation in computing through the support of courses like ECS and the creation of IDS, makes us uniquely qualified, confident, and well poised to design and launch a robust, STEM + Computer Science teacher residency pathway that 1) prepares novice and in-service teachers to effectively integrate computational thinking, computer science principles and theories, and interdisciplinary problem-solving into traditional STEM curricula; 2) provides an accessible, innovative pathway for STEM teachers to earn Computer Science Authorization; and 3) creates a robust California STEM+C^3 community of practice to sustain and scale STEM and Computer Science Pipelines.

PART 1. PROJECT DESIGN

STEM+C3 will prepare and license 48 STEM and Computer Science teachers and provide advanced professional learning for 16 - 20 accomplished STEM teachers to improve STEM teaching and learning for more than 8,000 students in four high needs comprehensive high schools. The STEM+C^3 vision aligns a humanizing teacher education program (Bartolome, 1994; Blume, 1971) with K-12 academic achievement standards, state and national content standards, the California Commission on Teacher Credentialing Teacher Performance Expectations (TPE), and California Standards for the Teaching Profession (CSTP). STEM+C^3 works on three integrated levels to firmly embed teacher learning and development in the context of urban schools and communities to support an ecology of teacher development over time:

novice teacher, mentor teacher, and communities of practice. (as described in Part III: Management Plan). Taken together, and detailed below, the vision, activities, and collaborative IHE-LEA management of STEM+C3 represents an exceptional approach for meeting statutory purposes and requirements.

GOAL 1: Design and Implement a Quality STEM+C Teacher Training and Mentor Teacher Development Program

In the context of innovative STEM-focused schools, pre-service teachers will engage in clinical learning alongside accomplished STEM mentors from the first day of school through the last (with continued, structured collaboration into the first two years of induction), using a gradual release co-teaching approach – reflecting an authentic apprenticeship model, which is the critical hallmark of effective teacher residency programs. This non-traditional teacher preparation approach provides a depth and breadth of clinical and coursework experiences for aspiring STEM teachers (Math, Science, Computer Science teachers). The curriculum will focus on developing teachers' understanding of how to integrate computational thinking and Computer Science Principles into instruction, in ways that align student learning to the ever-changing, technological driven, and data-centric world our students live in today. Key components of two NSF-funded, UCLA-developed curricula and professional development resources - *Exploring Computer Science* (ECS) and *Introduction to Data Science* (IDS) – will inform the re-designed STEM methods curriculum to deepen pre-service understanding and competence to align and engage computational thinking and Computer Science with the Next Generation Science Standards, Common Core State Standards (Mathematics) and interdisciplinary problem solving. Figure 1 provides a sample of how CT can transform STEM learning experience:

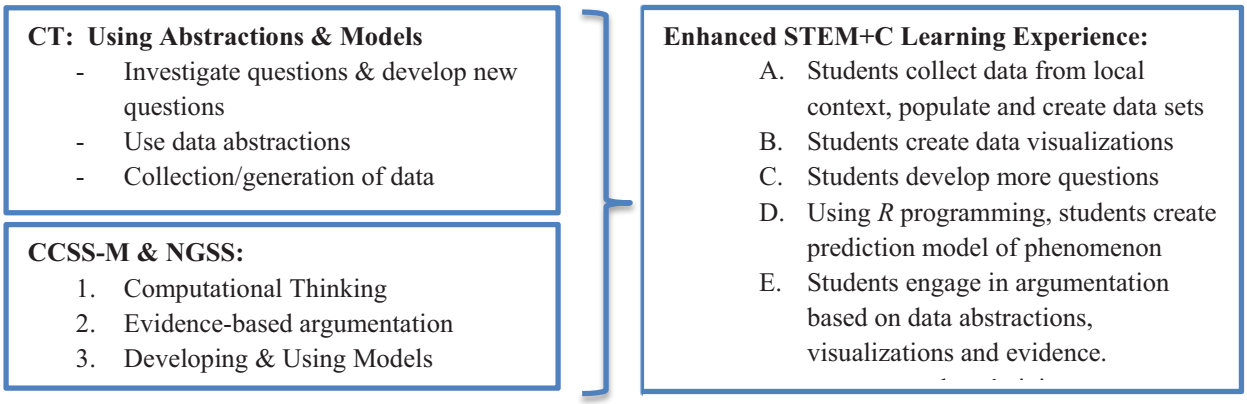


Figure 1. Sample STEM+C3 Learning Experience

The integration of CT into teacher preparation courses (e.g., subject matter methods and seminar courses) for math, science, and computer science teacher candidates, as well as clinical experience with a mentor, will provide rich, relevant and concrete learning experiences for pre-service teachers. As a result, we envision creating a community of teachers that move students from learning lists of disconnected science facts towards classroom experiences where students apply science concepts to solve "real-world" problems. We provide the following example to illustrate how a STEM+C^3 Biology teacher's curriculum design reflects a dramatic shift in the traditional, discipline-restricted curriculum typically used in underserved schools: *Because of her STEM+C^3 mindset, she knows that in order to authentically and deeply investigate phenomena, her students must engage in computational thinking. She decides to anchor her unit in the societal forces that generate "The Global Waste Stream" by having her students first examine their own waste production habits. She plans a series of learning experiences that provide opportunities for students to raise questions, define problems, and put forth solutions. To grab hold of the phenomena, her students must be able to breakdown problems and possible scenarios into more concrete investigable tasks (decomposition), so activities that activate her students' flexible and computational thinking are critical. As students collect data from a variety of*

sources, they quickly realize they need a way to make sense of the data and strategies for identifying larger patterns in data over time. By identifying meaningful patterns and developing data-centered generalizations her students will develop frameworks and guiding principles that can be applied to new scenarios in Biology, other curricula, and the world around them. This approach to teaching and learning is aligned to the Next Generation Science Standards and relies on students' ability to engage in meaningful Computational Thinking Practices to make sense of science.

Our goal is to recruit and prepare highly qualified secondary STEM teacher candidates and mentors who will be able to transform the STEM learning experience to be personally and authentically connected to students' local context and lives. Upon program completion, these STEM+C^3 teachers will possess the skills and capacity to provide accessible, rigorous, high quality STEM instruction to meet the needs of limited English proficient students, students with disabilities, and historically underserved and culturally diverse students. Three key objectives comprise this goal: 1) design a robust and replicable STEM+C^3 teacher education curriculum, 2) provide professional learning around CT and CS for novice/pre-service STEM teachers, 3) provide mentor support and CT and CS professional learning for mentor/in-service STEM and Computer Science teachers.

STEM+C^3—An Overview of the Curriculum

Guided by principles of social justice, the UCLA Center X Teacher Education Program (TEP) currently offers a fully accredited, robust teacher preparation program leading to CA Preliminary Mathematics and Science Teaching Credentials. The program includes intensive clinical experiences (i.e., 600+ hours of clinical fieldwork) that illuminate and deepen novice teachers' understanding of their extensive university coursework, making typically abstract

theory-practice connections visible and usable -- making the rhetoric of social justice pedagogies real. The program provides a strong foundation for the STEM+C^3 teacher preparation and support program. **Figure 2** visualizes the proposed STEM+C^3 teacher preparation pathway, that fully integrates and embeds computational thinking, computer science, and interdisciplinary problem-solving content and pedagogies into pre-service and in-service learning for novices and their mentors.

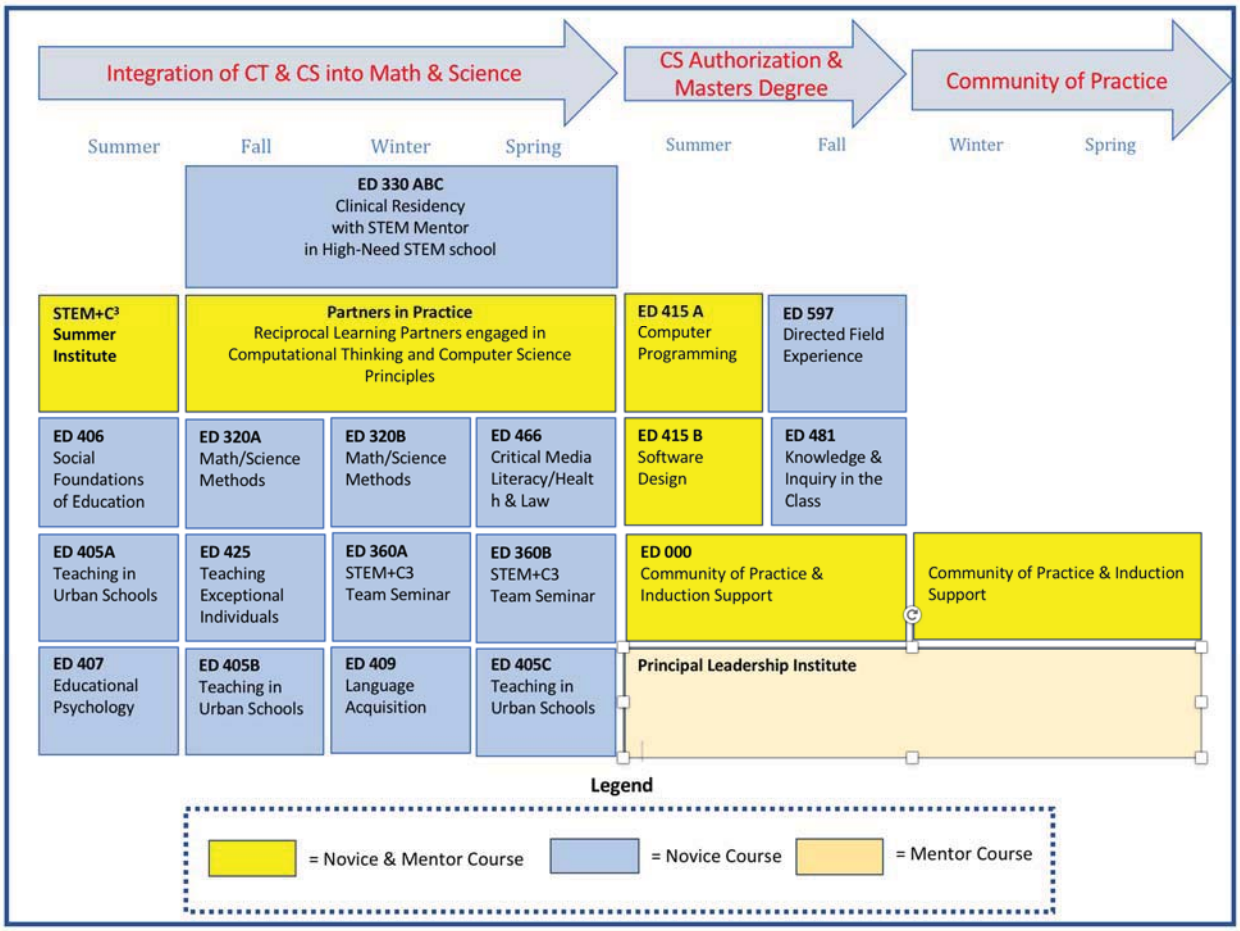


Figure 2. UCLA STEM+C^3 Residency-Mentor Curriculum

The first STEM+C^3 course (STEM+C^3 Summer Institute) will be offered during the summer before the school year begins and will bring together novices and their mentors in a week-long Summer Institute. The purpose of this initial Summer Institute is to provide a forum for STEM+C^3 participants to get to know one another, establish reciprocal learning relationships,

develop a framework for embedding computational thinking into math and science, and consider important issues of access and equity in STEM. The institute intends to provide a solid foundation upon which novice-mentor pairs will learn together throughout the year, particularly in the clinical residency and the continued Partners in Practice courses (ED330 series). During the yearlong Partners in Practice professional development space (90 hours), residents and their mentors will deepen their understanding of computational thinking as aligned to NGSS, CCSS and CS Standards and engage in a Lesson Study process focused on the development of STEM+C^3 units of study that elicit computational thinking at the core and engage in embedded cycles of reflection and revision.

Ongoing, Sustained STEM+C^3 Novice Learning

STEM-C^3 proposes a partnership wherein novice teachers and their mentors teach, learn and grow together. Triads of newly admitted novices, their mentor teachers, and university support providers will deeply collaborate throughout the entire program. Mentor teachers will support novice development and also engage in monthly content and pedagogical learning alongside their partner novice teachers (Partners in Practice in Year 1 and Community of Practice in Year 2). As described in **Figure 2**, novice teachers will have continued collaboration and reflection throughout their coursework, providing opportunities to meet specific needs of new STEM teachers. In addition, faculty that teach the ED 320 content methods series and ED 360 seminar series will collaborate with the STEM-C^3 instructors to ensure all courses coherently integrate CT and CS into their course curriculum.

Table 1 summarizes key elements of the program that both novice teacher and mentor will experience:

Table 1. Key Program Elements

	STEM+C^3 Novices	STEM+C^3 Mentors
Recruitment	Targeted annual recruitment of 16 STEM novice teachers (recent graduates of a 4-year IHE) from diverse pipelines including mid-career STEM+C professionals; particular emphasis on local talent who grew up and/or live in the communities serving STEM+C^3 schools	Targeted annual recruitment of 16 accomplished Math & Science teachers in identified high-needs schools, and engaged in Center X Science, Math, Computer Science for Equity and/or IDS projects
Selection	All prospective STEM+C3 candidates are required to submit an application and assessed by the STEM+C^3 Leadership Team for the following criteria: ● Strong content knowledge: ● UG degree and/or significant professional accomplishment in STEM field ● minimum 3.0 Jr/Sr GPA in STEM major ● passing scores of California Basic Skills Test and discipline specific California Subject Exam Test ● Strong letters of recommendation Strong verbal/written communication skills: ● social justice statement ● interview/audition 3-year service commitment in high needs school, teaching math, science and/or computer science	All STEM+C^3 mentor candidates are required to submit an application. Each application will be assessed by the STEM+C^3 Leadership Team. Mentor selection criteria includes: ● 5+ years of exemplary teaching, verified by CVUHSD teacher effectiveness scores in four key dimensions of teacher effectiveness: content knowledge, planning, content pedagogy, analysis and assessment of student learning (diagnostic and formative) and reflective practice ● recommendation by site supervisor ● Rubric-based classroom observation ● demonstrated ability to provide high quality, critical feedback to novice teacher candidates, via analysis of novice teaching video and subsequent feedback (scaled rating)
Cohort	Cohort-based team of 16 teachers paired with UCLA content and pedagogical experts/faculty and accomplished mentor teachers	A community of 16 mentors paired with STEM+C^3 novice teachers and UCLA content and pedagogical experts/faculty
Site	Placements in *innovative* STEM- focused high-need secondary schools; Partners in Practice professional learning; two years of personalized induction support; participation in STEM+C^3 Community of Practice	Teaching in *innovative* STEM focused high-need secondary schools; Partners in Practice professional learning; participation in STEM+C^3 Community of Practice
License	● Preliminary Teaching Credential in Math or Science ● Computer Science Authorization ● Master of Education degree	● UCLA STEM+C^3 Lead Teacher Certification ● Computer Science Authorization ● Master of Education degree through PLI
Stipe nds	$30,000 living stipend	$5,000 mentor stipend $6,000 stipend for mentors who elect to join PLI cohort

Ongoing, Sustained STEM+C^3 Mentor Learning

Research from Linda Darling-Hammond and the Learning Policy Institute (2017) found seven widely shared elements of effective professional development, that will inform the preparation for computer science teachers in UCLA-STEM+C^3 including: 1) **content focused** on computer science knowledge that is aligned with CSTA Computer Science Standards, ISTE Standards and Code.org Frameworks, 2) inquiry-focused CS instruction that incorporates **active learning**, 3) **collaborative, project based** learning among teachers and students, 4) **modeling** of effective classroom practice, 5) ongoing coaching and mentorship of experienced teachers, 6) opportunities for **ongoing feedback** and journaling to support a **reflective practice**, and 7) is **sustained** over three years. Drawing on this research, and to align with the design of the recognized Center X professional learning model and statutory guidelines, STEM+C3 mentor learning will be intentionally sustained, intensive, collaborative, job-embedded, data-driven, and classroom focused.

To drive mentor teacher learning and leadership and provide options that meet the varying professional development goals of accomplished mentors, STEM+C^3 will integrate various modes of teacher learning, structured supports for personalized learning, and encourage focused and productive collaboration by providing three mentor development pathways:

	STEM+C^3 Lead Teacher Certificate	CS Supplemental Authorization	Preliminary Admin Credential + M.Ed.
Courses	Summer Institute I Partners in Practice	Summer Institute I Partners in Practice Community of Practice ED 415 Series	Summer Institute I Partners in Practice Community of Practice Principal Leadership Institute

Table 2. Mentor Development Pathway

GOAL #2: Develop a Computer Science Authorization Pathway for STEM Teachers

A second goal of STEM+C^3 is to increase the number of CS authorized teachers to meet rising demands of K-12 Computer Science courses. In order to be CS authorized, California has identified required coursework, as described in Table 3. The STEM+C^3 Curriculum was developed to directly address these requirements. As organized in Table 3, year one will focus on data structures, algorithms, digital devices, and computing. Year two will deepen teachers understanding of computer programming and software design. Across this learning trajectory, all computer science concepts will be contextualized for the STEM classroom. Participants will learn that computer science is more than just developing students' capacity to use technology; through active engagement and deeper learning participants will understand the role of computational thinking, problem solving, algorithmic thinking, creativity and collaboration in the context of CCSS-M and NGSS.

Year 1 Summer Institute & Partners in Practice	Data structures and algorithms	Data representation, abstraction, searching and sorting in the context of solving problems using programming and computational tools
	Digital devices, systems, networks	Computer and communication devices and the systems they compose
	STEM+C3s of computing	The social, ethical, and legal issues and STEM+C3s of computing, as well as the contributions of computer science to current and future innovations in the arts, business, humanities, medicine, and science
Year 2 ED 415	Computer programming	Expertise in at least one modern, high-level programming language
	Software design	The process of planning, engineering, and implementing a software system to solve a problem, typically using both a design and a programming methodology

Table 3. California Computer Science Authorization Courses

UCLA experts from ECS, IDS as well as UCLA Faculty will collaborate on the design of each course. Leveraging IDS materials, we will teach coding using the *R* programming language, and deepen teachers' understanding of collaboration methodologies (like Agile), code reviews, Git, unit testing and integration. Once participants have gained experience using *R* to

analyze data, they will work in a small group to identify a large, multivariate dataset in an area of their choosing, and design and implement a Shiny web application or dashboard tool to assist an identified audience in answering statistical questions addressed to the dataset.

The combination of these materials coupled by expert collaborators from UCLA, will enable us to develop courses that directly support K-12 teachers' ability to understand programming to enhance their STEM curriculum, and prepares teachers to develop the content, knowledge and pedagogical skills to effectively teach Computer Science Courses. For example, in order to develop the ***ED 415A Computer Programming*** course, we will utilize existing ECS and IDS resources, collaborate with the UCLA Computer Science Department as well as the UCLA Statistics Department in order to design a Computer Programming Course for K-12 Educators. In particular, we will leverage material from ECS Units 3 and 4 which introduce students to the logic and processes of programming that are foundational to learning higher-level computer programming languages through activities such as web design with html and CSS, and animation and computer game building with Scratch. In addition, we will integrate IDS materials that deepens students' understanding of programming syntax and how to generate complex outputs (e.g., graphical plots) by writing and executing code. Similarly, we will collaborate with UCLA Computer Science and Statistics Faculty to develop a K-12 Software Design Course to develop the ***ED 415B Software Design***, the final requirements for the CS Authorization.

In addition, relationships with potential local STEM industry partners will be developed during the planning period to support the course design; these partners might include Honda, Raytheon, Lockheed Martin, Computer Sciences Corporation, Boeing, Chevron, Mattel, Northrop Grumman, the Los Angeles Air Force Base Space and Missile Systems Center, Tesla, and SpaceX -- all of which are located in communities surrounding the CVUHSD.

GOAL #3: Create a Robust California STEM+C^3 Community of Practice

The final goal of this proposal is to develop a STEM+C^3 Community of Practice that directly supports, sustains, and scales the STEM and Computer Science educator pipeline(s). The objectives of the proposed community of practice are to: operationalize the interdisciplinary nature of science, technology, engineering, and mathematics in STEM courses; integrate computational thinking and Computer Science concepts into NGSS/CCSS courses; and develop a critical mass of effective STEM+C teacher-leaders who can bring high quality STEM+C teacher learning and professional development to scale.

Discipline-specific communities of practice are long-standing arrangements in Center X. Each community of practice comprises content teacher leaders, professional development experts, and university faculty, all of whom bring critical knowledge, skills, and dispositions built upon the intersection of critical theory, research-based practice, community engagement, and social justice. Today, Center X's Math, Science and Computer Science for Equity communities of practice operate independently. To better align with the interdisciplinary approach of STEM+C^3, the existing Math, Science, and CSE communities of practice will come together to re-imagine and create an interdisciplinary, networked STEM+C^3 community of practice. To further broaden and strengthen the community of practice, we will invite the existing statewide California Subject Matter Projects network of mathematics and science teachers to participate. The newly formed community will engage in learning, collaboration, and networking through Summer Institutes, a virtual professional learning platform, webinars, and synchronous social media interactions (i.e., twitter #edchat, Google hangouts).

Teacher leaders within the STEM+C^3 Community of Practice will contribute back to the broader STEM+C^3 community as mentor teachers and professional development facilitators

(Summer Institutes and Partners in Practice); and will be poised to take on emerging roles as STEM and Computer Science instructional coaches.

The STEM+C^3 Community of Practice will not only support and sustain the STEM+C^3 pathway, but it will also scale and disseminate products which will extend the reach beyond the teachers that are immediately connected to the project. During the STEM+C^3 Summer Institute, math, science and computer science teachers will come together to develop resources for other educators. For example, we will create a website that will organize all resources in an accessible manner. We will upload all resources developed and used by STEM-C^3 teachers. During year one, teachers will work together to develop CT integrated Math and Science lessons and units. All of these resources will be vetted and uploaded for public use. The website will be publicized via existing social media outlets.

PART 2. LOCAL, STATE, AND NATIONAL SIGNIFICANCE

Located just 20 miles southwest of downtown Los Angeles, the Centinela Valley Union High School District is a high needs public school district that serves the working-class cities of Hawthorne, Lawndale, and Lennox. Its boundaries reflect deep socioeconomic contradictions of large urban areas across the country, with highly affluent communities to the west, and high poverty communities to the north and east. Once considered the "Aerospace Capital of the World", corporate downsizing displaced many aerospace workers; and while Hawthorne is home to tech giant SpaceX and Tesla, its more affluent neighbors to the west have been nicknamed "Silicon Beach", due to its evolution into a thriving center of high-tech manufacturing and information technology industry.

CVUHSD is comprised of three comprehensive high schools (Leuzinger HS, Hawthorne HS and Lawndale HS) and one Continuation School (Lloyde CHS), serving 6600 students.

CVUHSD school demographics are significantly different from the wealthy school districts to its west, and mirror those found in larger urban districts in the state:

- 90% of CVUHSD students are identified as economically disadvantaged
- CVUHSD's racially and ethnically diverse student body includes 75% Latino, 18% African-American, 3% Asian, and 2% White students in grades 9 - 12
- 12% of CVUHSD students are identified with special needs
- 14.4% of CVUHSD students are English Learners. The growth in the English Learner population is estimated to continue given that 37% of the total surrounding population is foreign-born.

CVUHSD has been a long-standing partner of both the UCLA Teacher Education Program and the UCLA Science Subject Matter Project (UCLASP). There are currently 49 UCLA TEP and Principal Leadership Institute graduates serving as teachers, coaches, and administrators in the district. UCLASP has helped facilitate the district's transition to the Next Generation Science Standards through a multi-year, district-sponsored coaching and Lead Teacher professional development program. These partnerships alongside a newer partnership with Center X's Introduction to Data Science program (IDS) has well-positioned the district to embark on STEM+C^3.

District needs have been identified based on data collected and instructional goals set forth in the CVUHSD's Local Educational Agency Plan (LEAP) and Local Control Accountability Plan (LCAP). The district has identified the following goals for LCAP which directly align with the plan set forth in STEM+C^3:

1. Provide all students access to fully credentialed teachers and instructional materials that align with state standards.

2. Implement California's academic standards, including the Common Core Standards in math.
3. Improve student achievement and outcomes along multiple measures, including test scores, English proficiency and college and career preparedness.
4. Ensure all students have access to classes that prepare them for college and careers, regardless of what school they attend or where they live.

STEM+C^3 will also address actions identified in CVUHSD LEAP which include improving student performance in mathematics and increasing access to Advanced Placement classes. Additionally, the proposed program directly aligns to CVUHSD's Title II plan with its focus on increasing student academic achievement by improving teacher and principal quality and increasing the number of highly qualified teachers in the classroom.

Critical STEM Teacher Shortage

CVUHSD, like many districts in California and throughout the nation, is facing a critical shortage of STEM teachers. As per the U.S. Department of Education, in 2015–16, 42 states reported teacher shortages in mathematics and 40 states reported shortages in science (U.S. Department of Education Office of Postsecondary Education. (2015). Despite its efforts, CVUHSD has consistently been challenged to fully staff its schools with credentialed STEM teachers. Every year for the last four years it has been forced to hire long-term substitute teachers to teach core classes in math and science. Long-term substitutes are individuals whose only qualification is a Bachelor's degree and who have not been prepared to teach the rigorous content needed to propel students to STEM majors and careers. This has become a standard practice among districts in California due to the shortage of qualified STEM applicants. In the 2017-2018 school year, 74% of California school districts reported that they were unable to fill

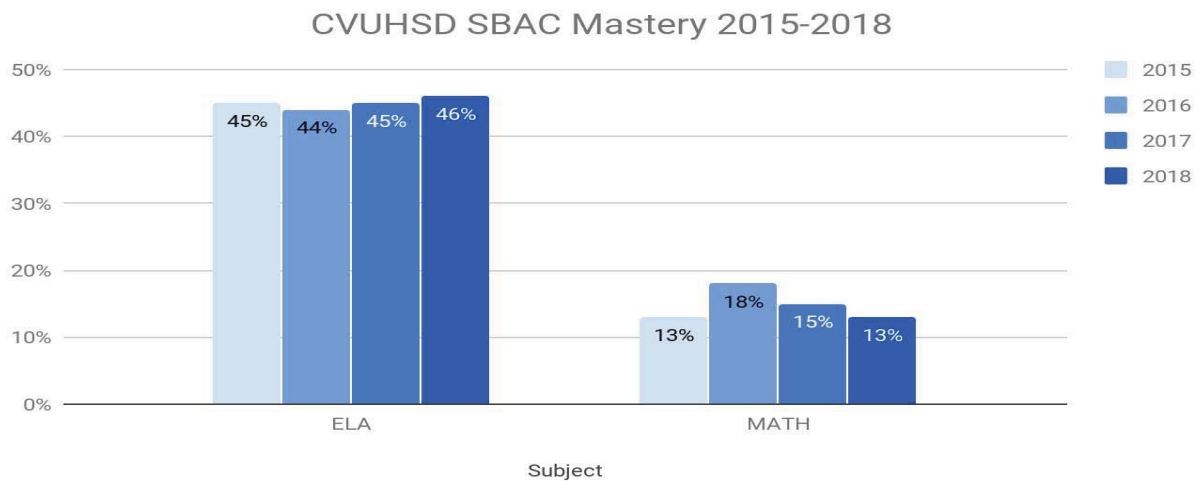
all their vacancies (Darling-Hammond, Sutcher, & Carver-Thomas, 2018). Of those districts, 82% had to hire underprepared teachers who had not completed the requirements for full certification with math and science representing acute shortage areas. (Darling-Hammond, Sutcher, & Carver-Thomas, 2018)

This situation has become dire over the last four years in CVUHSD as it strives to increase access to advanced STEM coursework through the establishment of science-based Career Technical Education Academies including a Marine Science Academy and a Biomedical Careers Academy. The district has also established math intervention classes, staffed at a 15 to 1 ratio, to assist students who are struggling to work at grade level. This, in turn, has added to the demand for math teachers. To fill unstaffed classes, this academic school year, CVUHSD has assigned 10% of its STEM faculty an additional class beyond their normal course-load to teach. STEM+C^3 will provide a much-needed pipeline to fully credentialed highly qualified math and science teachers with the knowledge and skills to support the needs of the district and ensure CVUHSD students a quality STEM education.

Increasing Student Success through Highly Qualified STEM Teachers

STEM+C^3 Mentor Teacher Development and Communities of Practice will ensure the retention of qualified teachers who can address STEM career and college readiness for CVUHSD students across all levels of the school system: the student level, the classroom level, the school level, and the district level. These programs will allow for teachers, administrators, UCLA TEP residents, and Center X partners to explore the factors that hinder CVUHSD students from meeting high school math and science standards and from being successful at post-secondary educational institutions.

Math Readiness - Student data from the California Assessment of Student Performance and Progress (CAASPP Smarter Balanced Assessment) which measures college and career readiness demonstrates an alarming pattern for CVUHSD. While English Language Art scores hover at a near 50% mastery level, only 13% of the District students achieved mastery in Mathematics in the 2017-2018 school year. Further, as demonstrated in Table 4 student scores have been falling from a "high" of 18% proficiency in the 2015-2016 school year.



Moreover, CVUHSD students continue to perform at the lowest level on this exam in skills related to showing and applying their problem-solving skills. In fact, in the past four years, an average of only 5.1% of students scored at or above standard in the area of problem-solving, modeling, and data analysis. There is great urgency to close the gap in student proficiency in mathematics to open future opportunities for all students.

STEM+C^3 focus on preparing and supporting STEM educators to engage students in computational thinking will both meet the needs of students who struggle to engage in computation proficiently and will provide professional learning for current CVUHSD teachers who face the challenge of integrating these skills into their curriculum in the absence of any real

guidance from either the Mathematics Framework nor the California Common Core Standards themselves.

Science Readiness - Similarly, while CVUHSD's Science teachers have worked diligently to align curriculum and instruction to the Next Generation Science Standards (NGSS), preliminary data from California Science Test (CAST), which measures student understanding of NGSS, is evidence that deeper and interdisciplinary work is needed. Of the 1475 CVUHSD's seniors who took the test in the 2017-2018 school year, 89% demonstrated a Moderate understanding of the NGSS standards. This test data is significant given the investment CVUHSD has made in developing their Science teachers understanding of NGSS. However, the data also demonstrates that no CVUHSD students scored at the highest level--having a "Considerate Understanding" of the NGSS standards. In order to prepare students for our 21st century world more is needed.

Table 5	**15-16**	**16-17**	**17-18**
	Mastery	**Mastery**	**Mastery**
Biology	35%	41%	66%
Chemistry	4%	62%	47%
Physics	14%	45%	43%

In addition, Common Core Science and NGSS-aligned common summative assessments, developed by CVUHSD Lead Teachers, provide a more focused examination of student need in science coursework. There have been significant gains made by students in those assessments from the 2015-2016 school year (Table 5). Teams of CVUHSD Science teachers have collaborated with the UCLA Science Project to develop storylines which incorporate the Next Generation Science Standards, 3-Dimensional Learning, and engineering and science practices. And yet, the data shows us that deeper work is needed to ensure that all students are college and career ready. Participating in the STEM + C^3 would enhance this transition to designing strong science-based interdisciplinary lessons and activities enriched with the integration of computational thinking.

Participating Mentor teachers and administrators will deepen their understanding of NGSS standard and Common Core Standards for Science and will enhance their ability to assess the rigor of their curriculum and whether it prepares students for college-level science courses. Districtwide the project will further build capacity of teacher leaders and administrators to reflect on the effectiveness and relevance of lessons.

Increasing Student Access to High-Quality Computer Science Classes

California expects an average of more than 20,000 computing job openings each year for the next five years, and yet technology companies are desperately competing for computing talent. Our economic foundation depends on this sector, which in turn depends on a well-educated and digitally savvy computing workforce. In a state challenged by deep social, economic, and educational inequality, creative thinking and innovation in interdisciplinary curriculum design and STEM and CS educator pathways -- the same kind of creativity and innovation that makes California a leader in the digital world—is needed to open up opportunities for all students.

State data show the paucity of computing courses overall in California schools, with fewer than 10% of students in grades 7 through 12 enrolled in a computing course. CVUHSD offers seven courses for its 6,600 students. Further state-wide, less than 1% of all AP exams taken in 2011 were in computer science. In CVUHSD in the 2018-2019 school year only one of its high schools is offering AP Computer Science. 77 students are enrolled in the class. An additional high school hopes to offer Computer Science Principles in the 2019-2020 school year. This lack of access to computing courses is true for all students, but it is particularly dramatic for girls and African American and Latinx students – students most underrepresented in computing occupations. Investments in STEM education, STEM educator preparation and support, and new academic content standards such as the Common Core Mathematics (CCSS-M) and Next

Generation Science Standards (NGSS) are intended to remedy the educational inequities that limit student outcomes in STEM and their full access to California's technological economy.

As the public becomes more supportive of efforts to scale up computer science education, researchers, practitioners, and advocates must remain vigilant to ensure these opportunities are available to all students and especially those who have long been underrepresented in computing, including girls and students of color. We are confident that our distinctive expertise in novice education grounded in social justice – and our position at the forefront of CS and data science education - make for a powerful chance to make such opportunities for access a reality.

Meeting the Demands of NGSS and Common Core in Traditionally Underserved Urban Schools

Today's students will live and work in a world that is heavily influenced by computing principles (Barr & Stephenson, 2011). Computational thinking (CT) has quickly become a prerequisite skill for many endeavors of the 21st century (Wing, 2008). In fact, in the last 20 years, nearly every field related to science and mathematics has seen the growth of a computational thinking. The practice of ''using mathematics and computational thinking'' in NGSS reflects the growing importance of computation and digital technologies across the scientific disciplines. The Common Core framework in mathematics also states that students should be able ''to use technological tools to explore and deepen their understanding of concepts'' (National Governors Association 2010, p. 7). In addition, recent innovations in CS education, in particular discussions around Exploring Computer Science (ECS) and Computer Science Principles (CSP), highlight the importance of inquiry and equity-based practices to broaden access and participation in computing. While expectations for teachers to integrate computational thinking into Math and Science coursework is clear, the inclusion of these

practices into standards, in and of itself, offers little guidance for teachers who will be required to realize them in their classrooms.

Bringing computational tools and practices into K-12 mathematics and science classrooms prepares students for pursuing STEM, creating a pipeline to STEM professions, and develops STEM-literate citizens and future decision-makers/voters. From a pedagogical perspective, the meaningful integration of computational thinking opportunities into STEM curricula can deepen learning of mathematics and science content (Guzdial 1994; National Research Council 2011a, b; Redish and Wilson 1993; Sengupta et al. 2013; Sherin 2001; Wilensky 1995; Wilensky et al. 2014; Wilensky and Reisman 2006). Most importantly, by embedding computational thinking into mathematics and science classrooms, we can address the fact that only a fraction of high school students has an opportunity to take computer science courses.

Addressing California's Shortage of Computer Science Teachers

Large urban school districts including New York, Chicago, Los Angeles, and San Francisco have unveiled ambitious plans to integrate computer science in K-12 education, and governors from states like Arkansas, Utah, and Idaho have initiated statewide plans to make computer science a requirement toward high school graduation.

As California creates its own ambitious K-12 Computer Science plan, it currently faces a critical shortage of CS teachers (Darling Hammond, 2016) as schools struggle to respond to the increasing demand for CS courses in high school. None of CVUHSD Math or Computer Science teachers has an authorization to teach Computer Science. Computer Science teachers in California must possess one of the following authorizations: 1) a single-subject credential in math, business, or industrial technology; 2) a Designated Subjects Credential in Career Technical

Education, with an authorization for Information and Communication Technologies (ICT); or 3) Supplementary Authorization in Computer Concepts and Applications (CCA). None of these licensure pathways requires credential candidates to engage in CS coursework, learn CS pedagogies, or complete fieldwork in CS classrooms. As a result, teachers authorized to teach Computer Science in California enter CS classrooms with inadequate novice training, in schools that offer little if any CS professional development; creating a vacuum of quality computer science education for K-12 students, particularly students in high-need schools, which are far too often staffed by novice teacher teachers (Borman & Dowling, 2017).

Over the past several years, the California Commission on Teacher Credentialing (CTC) has engaged a series of conversations with representatives from ACCESS and the Computer Science Teachers Association (CSTA) about the current preparation and authorizations for teaching the range of K-12 Computer Science classes in California schools. Because the discipline of Computer Science for K-12 students has changed; coursework offered in Computer Science in California public schools has evolved rapidly in recent years, while the required Content Areas of Study for the Supplementary Authorization in CCA have remained the same since first developed in 1987. With support and encouragement from ACCESS, June 2015, the CTC took action to approve proposed amendments to Title 5 regulations pertaining to the Supplementary Authorization in CCA to strengthen the required Content Areas of Study for the Supplementary Authorization. The proposed regulations strengthen the required Content Areas of Study for the Supplementary Authorization to ensure holders have the requisite content knowledge to teach the scope of Computer Science classes now offered in California public schools. To reflect the broader approach to this content area, the proposed regulations include

changing the name from Computer Concepts and Applications to the Supplementary Authorization in Computer Science.

Impact on Teacher Education

STEM+C^3 continues to position UCLA TEP at the forefront of preparing quality teachers with the content knowledge, pedagogical skills and critical dispositions essential to teaching in urban schools; and will allow us to persist in our efforts to create high-quality, accessible pipelines to teaching for candidates of color committed to serving our most vulnerable students. STEM+C^3 stands to fundamentally transform the way STEM teacher preparation curricula are designed and implemented at UCLA to meet the growing needs of our diverse 8-12 grade students in urban schools through thoughtful, interdisciplinary collaborations among content and pedagogical experts that cut across titles and institutions -- STEM+C^3 treats effective educator development as "our" responsibility. Further, by taking an interdisciplinary, problem/phenomena-based approach to STEM, teacher candidates will enter classrooms poised to tap into their students' curiosity and engage them in the depth and complexity of STEM learning in ways that traditional approaches limit. Finally, STEM+C^3 breaks the cycle of traditional "master" and "student" teacher relationships, creating a shared ecosystem of teaching and learning wherein novices and mentors learn and grow together. Collectively, STEM+C^3 will initiate important shifts in approaches, mindsets, and ways of working together that will become part of the ethos of UCLA TEP.

Broad Dissemination to Enable Others to Use STEM+C^3 Strategies

In 2018 the IDS team prioritized an expansion of data science education to teacher education programs throughout California. As a first step, in spring 2018, IDS developers and coaches held a symposium for TEP leaders from California Institutions of Higher Education to

share expertise and lessons learned about how to best prepare novice teachers for teaching in a world of data, to encourage TEP leaders to see data science as a critical concept that would support new teachers' understanding of the new standards, and to discuss how we might grow a community among novice teacher educators to foster data science education. As a collective, these experts explored ways in which teacher preparation programs might reimagine the way we prepare our teachers and create a community of practice to integrate computational thinking, statistical thinking, and data science concepts into NGSS/CCSS courses.

If funded, our aim is to springboard this type of community of practice conversation to disseminate the work of STEM+C^3 to teacher education programs throughout California - and ultimately nationwide - by leveraging national science and mathematics conferences, continuing to publish findings (i.e., white papers, press releases, brochures, infographics, policy briefs, articles), and holding additional symposia, webinars, and data science conferences. Additionally, resources and materials developed at current and future summer institutes would be disseminated to TEP programs and school districts interested in replicating and, in turn, disseminating these products, with the ultimate goal in mind of growing a nationwide STEM+C community to bring high quality STEM and Computer Science teacher learning and professional development to scale. All resources will be vetted and uploaded to an open source website for public use, and publicized via existing social media outlets

PART 3. RESOURCES

The UCLA STEM+C^3 urban teacher residency program will be managed by UCLA as lead partner, in close collaboration with Centinela Valley Union High School District and ACCESS. UCLA Center X employs approximately 300 educators and other personnel, supported by an administrative unit that oversees several large federal and state grants, contracts, and sales

and service accounts. As a unit within the UCLA Graduate School of Education and Information Studies (GSE&IS), Center X is also supported by the GSE&IS Business Office and Office of External Relations, as well as the UCLA Office of Contracts and Grants. In addition to being part of a well-supported Institution of Higher Education, Center X has a long track record of collaborating with Centinela Valley Union High School District, ACCESS, and a range of other K-12, university, non-profit, and community-based educational partners.

Collaboration of Key Partners

STEM+C^3 was developed by a trio of partners: ***UCLA Center X***, the ***Centinela Valley Union School High School District***, and the ***Alliance for California Computing Education for Students and Schools*** (ACCESS). The proposed project will be managed by UCLA as lead partner, with oversight from the broader partnership. UCLA will be responsible for building a staff, delivering an effective residency and professional development program, achieving financial sustainability, and assuring assessment and evaluation.

UCLA Center X, part of the #1 Graduate School of Education in the country (US News and World Report, 2018), is an equity-focused K-12 educator preparation, development, and support community whose mission is to *transform public schools to create a more just, equitable and humane society*. Center X is comprised of 14 equity-focused educator preparation and professional development projects/programs, including four that make up Center X's STEM+C^3 network: The UCLA Teacher Education Program, the Computer Science for Equity Project, the UCLA Science Project, and the Principal Leadership Institute@UCLA:

- The *Teacher Education Program* (TEP) is a fully-accredited, social justice-focused educator preparation program which pioneered the hugely successful UCLA Urban Teacher Residency Program. Mindful of the power of community schools and

community educators, TEP recruits diverse candidates who possess exceptional content knowledge, experience in urban settings, a commitment to social justice and an ethic of care, and a willingness to collaborate within a community of practice. Their graduate retention rate in urban schools far exceeds the national and state average. Each year, TEP will recruit and select 16 accomplished STEM students and mid-career professionals (career changers) from diverse backgrounds to participate in STEM+C^3. In this effort it will join with the CVUHSD and its community partners to identify and recruit prospective residency candidates including CVUHSD alumni who have excellent math and/or science knowledge and skills, and local STEM professionals interested in pursuing teaching as a second career. TEP will also collaborate with CVUHSD to identify highly qualified mentors for the residency program and will team with its Center X colleagues to develop the STEM+C^3 TEP curriculum.

- The mission of the *Computer Science for Equity Project* (CS4E) is to increase and enhance computer science learning opportunities in LAUSD and nationwide, and to broaden the participation of African-American, Latino/a, and female students in learning computer science. Exploring Computer Science, has been supported along with our University of Oregon partners, and is currently taught in over 30 high schools in LAUSD and has been disseminated to 25 states, the 7 largest school districts in the nation, and Puerto Rico. Since its full implementation in 2014, IDS is offered in 30 schools in LAUSD and 6 smaller districts in southern California, with plans for implementation in 8 additional districts in 2018-2019. CS4E is a critical thought partner for the work of STEM+C^3 and will inform the development of the STEM+C^3 TEP curriculum and

secondary unit and lessons, and actively participate in classroom observations and feedback loops.

- With the vision of transforming science classrooms, the *UCLA Science Project* partners with teachers from districts and schools to develop professional learning opportunities for K-12 teachers. Using adult learning theories, the Science Project strives to build a culture of collaboration and respect among teachers, while highlighting advances in research that affect the classroom. The Science Project will lead the development of the STEM+C^3 TEP curriculum (Summer Institute, Partners in Practice, Methods and Seminar Courses). In addition, the Science Project will support TEP faculty as they better align other Resident and Graduate year courses to integrate CT and CS opportunities in ways that align with the CCSS and NGSS.
- The *Principal Leadership Institute (PLI)* is a fully accredited administrator preparation program designed to attract outstanding educators who are interested in assuming leadership roles and dedicated to serving in the most underserved communities in the greater Los Angeles area. PLI will reserve 8 slots each year for STEM+C^3 mentors interested in pursuing an administrative credential + Master of Education degree.

The Centinela Valley Union High School District is home to 3 comprehensive high schools and one continuation high school. In 2017-2018 74.5% of its 6600 students received free and reduced lunch, a marker of poverty in schools. The District is committed to providing an educational environment in which all students have been prepared for the challenges of higher education and the future demands of a modern technological society. As a partner in STEM+C^3 the district commits to assisting with the recruitment of prospective residency candidates including CVUHSD alumni who have excellent math and/or science knowledge and skills, and

connecting with local organizations to identify STEM professionals interested in pursuing teaching as a second career and/or providing industry-facing learning opportunities for STEM+C^3 participants. The district commits to hosting 16 residents each year for the duration of the grant and will collaborate with Center X to identify highly qualified mentor teachers to support STEM+C^3 residents. CVUHSD will also facilitate participation of in-service Math and Science teachers in the STEM+C^3 Communities of Practice and CS Pathways.

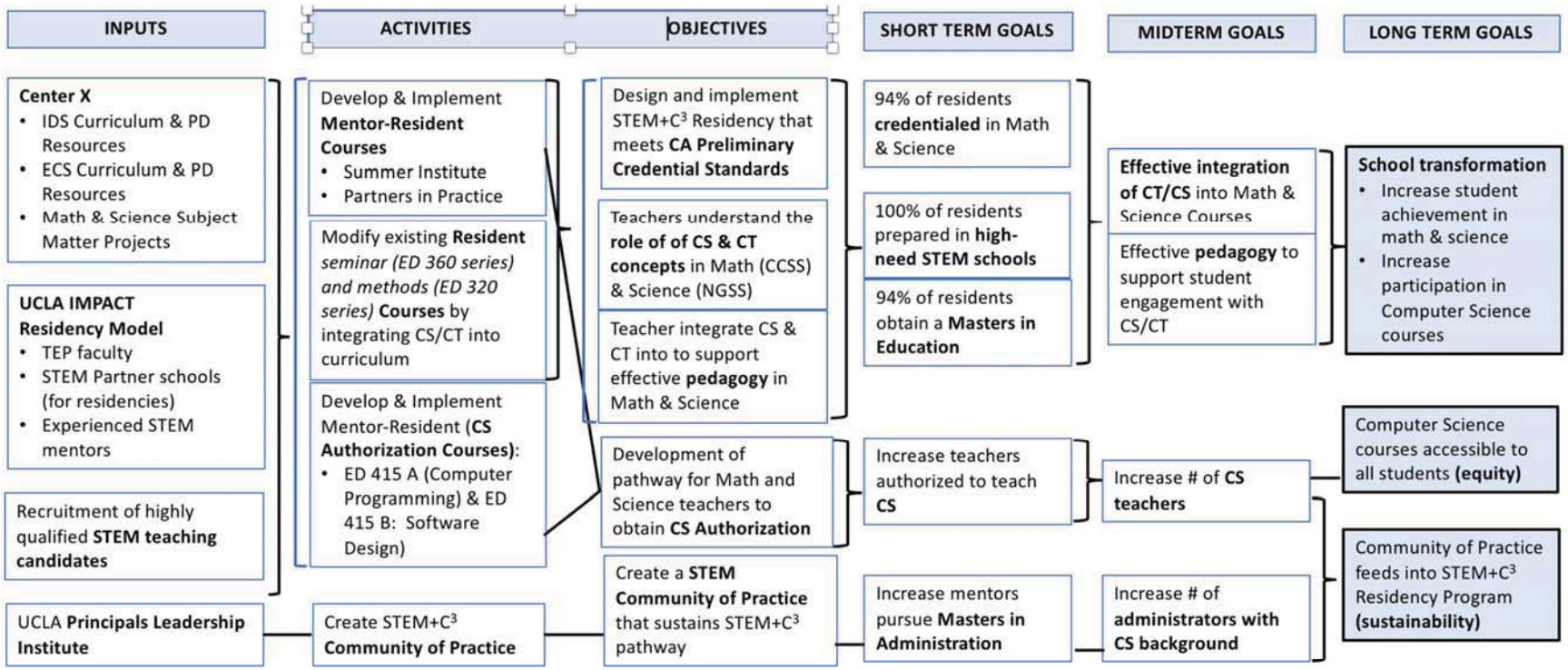
The Alliance for California Computing Education for Students and Schools (ACCESS) is a statewide network of computer science stakeholders: school district administrators, K-12 teachers, higher education leaders, non-profits, policy advocates, industry professionals, and elected officials. Since 2012, ACCESS has been dedicated to advocating for high-quality K-12 computer science education and ensuring access to all students, specifically underrepresented students in CS: girls, students of color, and low-income students. One of the many goals of ACCESS - a goal that is central to the STEM+C^3 vision -is to establish a computer science certification pathway for K-12 teachers in California, and to ensure that quality professional development is available to these teachers. ACCESS has been leading the charge to support the development of a CS Authorization Pathway and will advise the STEM+C^3 team to stay aligned to the ever-changing CS Policy. ACCESS will serve as a critical thought partner and local, state, and national policy advocate.

PART 4. MANAGEMENT PLAN

Clearly Specified and Measurable Goals, Objectives, and Outcomes

With over 25 years of experience in the development and implementation of a rigorous and forward-thinking STEM teacher preparation pathways rooted in the mission of educational access for the most underserved students - combined with 10+ years of championing the

broadening of participation in computing movement through pioneering curricula like Exploring Computer Science (ECS) and Introduction to Data Science (IDS) - our team is uniquely poised to launch the innovative and groundbreaking STEM+C^3 teacher preparation pathway visualized in the logic model and program summary tables below:



Project Measures:

- STEM+C^3 teachers will demonstrate effectiveness based on multiple measures, including edTPA, observation ratings, and instructional logs
- STEM+C^3 teachers and mentors will demonstrate fluency in computational thinking as measured by the LOCUS assessment
- Multiple measures will be used to measure program characteristics and participants attitudes about key STEM+C^3 constructs, including surveys, interviews, and focus groups
- Teacher retention rates of STEM+C^3 teachers will exceed by 5% those of a matched comparison group of first-time teachers
- Multiple measures of mentor effectiveness, including surveys/logs of mentoring practice, feedback quality measure, and faculty evaluations
- Academic growth over time (on common strands of the CAASPP) of STEM+C^3 teachers will exceed a matched comparison group of first-time teachers

Goal 1: By June 2020, design and begin implementation of a STEM+C^3 Teacher Training that meets California teacher credentialing standards for the Preliminary Single Subject Authorization (Math/Science) and Computer Science Supplemental Authorization.
Create STEM+C^3 teacher preparation and mentor development curriculum that includes: • One -week Summer Institute that introduces a framework for embedding computational and statistical thinking into Mathematics and Science • 3-quarter (90-hour) Partners in Practice PD series to deepen resident and mentor understanding of embedded computational and statistical thinking, develop units of study that elicit computational thinking, and engage cycles of reflection and revision • continuous cycles of classroom observation and feedback that engages STEM+C^3 experts to refine the newly designed curricula
Recruit, select, and prepare 48 (16 per year) mathematics and science novice teachers in an innovative STEM+C^3 teacher preparation pathway
Pair novice teachers with accomplished mentor teachers in innovation STEM+C^3 focused secondary schools in Centinela Valley Union High School District
Participate in 90 hours of CT and CS professional development alongside mentor teachers
Residents co-construct and deliver CT-focused math and science units that support secondary students' sense-making in math and science
Recruit, select, and support 48 (16 per year) mathematics and science mentor teacher candidates in innovative STEM+C schools
Participate in 90 hours of CT and CS professional development with novice teachers
Co-construct and deliver CT-focused math and science units that support secondary students' sense-making in math and science
Create pathways and provide financial support for mentors to earn advanced credentials (CS Authorization, Preliminary Administrative Services Credential, Masters in Education degree)
Outcomes: 1) Create replicable TEP Curriculum with focus on CT and CS integration into STEM courses. 2) Develop teachers that effectively engages students in STEM by way of CT and CS practices and tools. 3) Create pool of STEM teachers that are inspired and prepared to pursue CS Authorization.

Goal 2: Develop a Computer Science Authorization Pathway for STEM Teachers
Integrate CS Authorization coursework into STEM+C^3 pathway
Recruit STEM mentor teachers to pursue CS Authorization
Modify and Implement ED 330 Partners in Practice course sequence
Develop & Implement Computer Programming Course
Develop & Implement Software Design Course
Outcomes: 1) Increase pool of CS authorized teachers; 2) Develop effective CS teachers

Goal 3: Create a Robust California STEM+C Community of Practice (CoP)
Recruit existing Center X Math, Science, CS CoP participants to form STEM CoP
Recruit STEM+C^3 participants to join STEM Community of Practice
Develop STEM Community of Practice **Summer Leadership Institute**
STEM CoP participants serve as future "mentor" teachers & PD/Course Facilitator/Lecturer
Outcomes: 1) Scale & Sustain Robust STEM Community of Practice, 2) Develop website to disseminate all resources and teacher-developed materials

(Note: Project objectives and quantitative and/or qualitative performance measures can be found in the required grant application form)

STEM+C^3 Timeline and Milestones

The STEM+C^3 Program seeks to recruit, prepare and retain 48 (16 per year) highly competent urban teachers in the high-need areas of math, science, and computer science, and to engage 16 accomplished STEM+C mentor teachers each year in advanced professional learning. Novices will be trained within an enhanced cohort-based residency program that situates learning in three (3) comprehensive high schools in high-need communities of Lawndale, Hawthorne and Lennox which the Centinela Valley Union High School District serves. In addition, the program is premised on the value of novice teachers learning alongside accomplished mentors, and strives to develop, support, and certify these mentors as skilled, licensed computer science teacher leaders. Finally, STEM+C^3 seeks to create retention-oriented communities of practice that allow good teachers and teaching to flourish. Project timeline and milestones associated with these three goals are displayed in Table 6.

UCLA STEM+C3																	
Annual Project Tasks				Planning & Recruitment			STEM+C3 Residency Mentor Year				CS + Cred + M.Ed.				STEM+C3 Community of Practice			
	Lead	Start Date	End Date	Fall '19	Wtr '20	Spr '20	Sum'20	Fall '20	Wtr '21	Spr '21	Sum'21	Fall '21	Wtr '22	Spr '22	Sum'22	Fall '22	Wtr '23	Spr '23
TEP STEM+C3 Curriculum Redesign																		
STEM-C Coursework Revision/Development	Kim-John	10/01/19	01/31/20															
Pilot with Existing Lead Teachers	Kim-John	02/01/20	05/29/20															
Improvement Cycles	PLT	02/01/20	08/31/20															
				Planning & Recruitment			STEM+C3 Residency Mentor Year				CS + Cred + M.Ed.				STEM+C3 Community of Practice			
				Fall '19	Wtr '20	Spr '20	Sum'20	Fall '20	Wtr '21	Spr '21	Sum'21	Fall '21	Wtr '22	Spr '22	Sum'22	Fall '22	Wtr '23	Spr '23
Apprentice Learning																		
Recruitment & Selection	Director	10/1/19	4/30/20															
STEM+C Summer 'Partners in Practice' Course	Faculty	7/1/20	8/31/20															
Clinical Residency	Mentors	7/1/20	6/30/21															
Monthly Partners in Practice Course	PLT	10/1/20	6/30/21															
Culminating Performance Assessment	edTPA Coord	4/1/21	4/30/21															
Preliminary Credential Recommendation	Student Serv	6/1/21	6/30/21															
Summer CS Authorization Courses	IDS/ECS	7/1/21	8/31/21															
CS Authorization Recommendation	Student Serv	8/1/21	8/31/21															
Full-time STEM+C Teacher of Record	CVUSD	9/1/21	6/30/22															
Induction Year (Community of Practice)	UCLA+CVUSD	9/1/21	6/30/22															
Masters in Education Courses	Faculty	9/1/21	6/30/22															
Masters in Education Degree	TEP Dir	6/1/22	6/30/22															
Induction Support Yr2 (Community of Practic	UCLA+CVUSD	9/1/22	6/30/23															
				Planning & Recruitment			STEM+C3 Residency Mentor Year				CS + Cred + M.Ed.				STEM+C3 Community of Practice			
				Fall '19	Wtr '20	Spr '20	Sum'20	Fall '20	Wtr '21	Spr '21	Sum'21	Fall '21	Wtr '22	Spr '22	Sum'22	Fall '22	Wtr '23	Spr '23
Mentor Learning																		
Recruitment & Selection	Director	10/1/19	4/30/20															
STEM+C Summer 'Partners in Practice' Institut	Faculty	7/1/20	8/31/20															
Clinical Residency (as Mentor)	Mentors	7/1/20	6/30/21															
Monthly Partners in Practice PD	PLT	10/1/20	6/30/21															
Summer CS Authorization Courses	IDS/ECS	7/1/21	8/31/21															
CS Authorization Recommendation	Student Serv	8/1/21	8/31/21															
STEM-C3 Community of Practice	UCLA+CVUSD	9/1/21	6/30/22															
Principles Leadershp Institute	PLI	9/1/21	6/30/22															
Administrative Credntial	PLI	6/1/21	6/30/22															
STEM-C3 Community of Practice	UCLA+CVUSD	9/1/22	6/30/23															
				Planning & Recruitment			STEM+C3 Residency Mentor Year				CS + Cred + M.Ed.				STEM+C3 Community of Practice			
				Fall '19	Wtr '20	Spr '20	Sum'20	Fall '20	Wtr '21	Spr '21	Sum'21	Fall '21	Wtr '22	Spr '22	Sum'22	Fall '22	Wtr '23	Spr '23
Project Management Meetings																		
Monthly Leadership Team	PI/Director																	
Monthly Professional Learning Team	Director																	
Quarterly Advisory Board	PI/Director																	

.STEM+C^3 Project Management Structures, Roles, and Responsibilities

In order to ensure all goals and outcomes are met, the STEM+C^3 Project Director will organize and lead Monthly Leadership Meetings, Monthly STEM+C^3 Professional Learning Team Meetings and STEM+C3 Quarterly Partner Meetings:

Monthly STEM+C^3 Leadership Team Meetings (12 per year) - The leadership team will have 3-hour monthly meetings to discuss all facets of program planning, ongoing function and sustainability, assess program implementation, engage in inquiry cycles of improvement, and coordinate subsequent feedback loops. Although working with multiple partners is an asset to the work – bringing enormous resources to leverage school transformation – partnerships present coordination and management challenges. The leadership team will ensure that the program is well-orchestrated and that all partners participate in meaningful ways. Each partner has agreed to collaborate with the others to create this program and a system of checks and balances that provide the lead partner with necessary guidance and support to ensure the success of the model. During the design year (Y1), a detailed MOU will be created and signed by each partner to clearly define the roles and responsibilities of each.

The Leadership Team is ultimately responsible for building a professional staff, delivering an effective STEM+C^3 residency program, achieving financial sustainability, and assessment and evaluation and includes (*see resumes in appendix)*:

Annamarie Francois Principal Investigator Executive Director, UCLA Center X	Oversee all facets of the program and lead the work (in collaboration with project evaluators) related to research and evaluation, including but not limited to: data collection, database management, database maintenance, human subjects approval, district data access and agreements, annual reporting of GPRA measures, presentation of findings, professional development for data-driven inquiry, etc. In addition, PI will work with the Center X Senior Fund Manager to actively monitor the budget
Emma Hipolito, Co-Principal Investigator Director, UCLA Teacher Education Program	Integrate STEM+C^3 into the existing TEP; provide high-level leadership support to STEM+C^3, including working with UCLA and CVUHSD officers to develop financial sustainability options for residency preparation program after the life of the grant; will share responsibility for annual performance reporting of STEM+C^3 with the Principal Investigator
TBD, Director, STEM+C^3 Residency Program	Plan and oversee the programmatic aspects of the STEM+C^3 Pathway; work with STEM+C^3 faculty and partners to develop and implement a rigorous residency program and teacher assessments aligned with the California Standards for the Teaching Profession, California Teacher Performance Expectations, California Common Core Standards (including college- and career-ready academic standards) and Next Generation Science Standards; translate those standards into effective classroom practice; and provide daily support to STEM+C^3. Co-lead the curriculum redesign and professional development activities of STEM+C3 (1 FTE)

Monthly STEM+C^3 Professional Learning Team Meetings (12 per year) STEM+C^3 faculty, STEM+C content experts, and select members of the Leadership Team will convene during 3-hour monthly meetings to share emerging problems of practice, strengthen curriculum, improve instructional strategies and supports, use date-driven inquiry to understand novice teacher learning and enhance the STEM+C^3 experience, and support one another in being effective teacher educators. The Professional Learning Team includes:

- [redacted], Director of K12 Initiatives, National Center for Women & Information Technology
- [redacted], Director, CVUHSD Curriculum and Instruction Unit
- [redacted], Director, UCLA Center X Teacher Education Program
- [redacted], Director, UCLA Center X Science Programs & CA Science Project
- [redacted], Faculty, STEM Education, UCLA Center X Teacher Education Program
- [redacted], Specialist, UCLA Center X Introduction to Data Science Program
- [redacted], Faculty, STEM Education, UCLA Center X Teacher Education Program
- [redacted], Director of Research, UCLA Center X Computer Science for Equity Program

STEM+C3 Quarterly Partner Meetings (4 per year) will bring together representatives from each partner to keep partners informed of each unit's activities, progress, goals, and needs to meet STEM+C^3 objectives, to keep all partners accountable and responsible for their individual responsibilities to the project, and to keep project goals at the fore.

STEM+C^3 Advisory Board Meetings (2 per year) will bring together a group of individuals who bring expert knowledge and skills that augment the KSAs of STEM+C^3 leadership, faculty, and content experts. The UCLA STEM+C3 Advisory Board includes:

- [redacted], Executive Director, ACCESS and Director, Computer Science for Project, UCLA
- [redacted], Faculty, UCLA Department of Statistics and Principal Investigator, NSF Mobilize/IDS Grant
- [redacted], CVUHSD, Science Instructional Coach, CVUHSD
- [redacted], Professor, UCLA Graduate School of Education & Information Studies, Division of Urban Schooling
- TBD, STEM Industry Partner

Transparent, Legally Binding Agreements between STEM+C^3 and All Residency Participants

UCLA's Center X will oversee contracts with all residency program partners. Apprentices will be paid a $30,000 living stipend. Service will be verified with a copy of an employment contract, and quality teaching will be assessed by the faculty advisor, mentor teacher, principal, and district human resource specialist using two tools: 1) the UCLA STEM+C^3 Classroom Observation Rubric, and 2) the CVUHSD Teaching and Learning Framework. First and second year teachers are considered probationary, and if given a below-standard evaluation either year (not meeting the requirements to be a highly qualified teacher), they will be released from their employment contract and counseled out of the profession. Any STEM+C^3 teacher who does not

complete the 3-year service obligation (for reasons other than health, being called to active duty in the Armed Forces of the United States, or other extraordinary circumstances) will be required to repay the stipend with interest to UCLA STEM+C^3. These recovered funds will be put into the budget supporting improved recruitment and support strategies for the next year's cohort. All mentors will be paid a $5,000 stipend and will have the opportunity to provide STEM+C^3 professional development for an additional amount; any mentor choosing to join the Principal Leadership Institute will be provided $3000 in tuition support. Any mentor teachers who do not meet their obligations will be released from their mentor teacher duties and asked to repay their stipend(s).

PART 5. EVALUATION

UCLA's National Center for Research on Evaluation, Standards, and Student Testing (CRESST) has been a nationally and internationally known force in educational assessment, research, and evaluation for over 50 years. CRESST projects focus on bringing innovation to the design, understanding, implementation, and use of assessments, evaluation, and related supports. CRESST has been engaged in the evaluation of Center X's teacher training programs for the past 15 years, including the two teacher training projects funded under the Teacher Quality Partnership (TQP) Grant Program in both 2009 and 2014.

For the current proposed evaluation work, [redacted] will continue to serve as the lead evaluators as they were for the previous two projects. This will give Center X the benefit of having an evaluation team with a deep understanding of its goals and strategies, and with access to a wide range of evaluation tools and instruments that can be easily augmented to fit the focus of the STEM+C^3 program.

The current proposed study will be a comprehensive mixed-method evaluation. This will involve the collection and/or analysis of multiple primary and secondary data sources to examine the following questions about the characteristics and outcomes of the STEM+C^3 program.

1. **Program Characteristics**

   a. To what extent do novice and mentor teachers engage with core STEM+C^3 program activities?
   b. How do the mentor teachers and partner site administrators interact with and engage in the training process of the novice teachers?
   c. What does participation look like in the STEM+C^3 community of practice?
   d. What does student participation look like in the STEM+C^3 courses?
   e. What are the perceived benefits of participating in the program?

2. **Outcomes: GPRA Measures**

   a. What are the initial certification rates for the STEM+C^3 graduates?
   b. What are the initial certification rates for the STEM+C^3 graduates in Math/Science?
   c. What are the one-year persistence rates for the STEM+C^3 participants?
   d. What are the one-year employment retention rates for STEM+C^3 completers?
   e. What are the three-year employment retention rates for STEM+C^3 completers?
   f. [Pending the availability of an adequate sample and district data] What were the learning outcomes of students taught by STEM+C^3 completers?
   g. What are the computer science certification rates for the STEM+C^3 completers and mentor teachers?

3. **Outcomes: Program Foci**

   a. What are the outcomes of participation on the attitudes of STEM+C^3 cohorts of novice and mentor teachers regarding key program foci?
   b. What are the outcomes of program participation on the fluency of STEM+C^3 cohorts of novice and mentor teachers regarding key statistical thinking constructs?
   c. Do STEM+C^3 novice teachers develop proficiency in their performance regarding the teaching of STEM and statistical thinking units?

d. What are the computer science authorization and master's in administration degree completion rates for the mentor teachers?

Research Design

CRESST will use a comprehensive multiple measures approach including both quantitative and qualitative data. In collaboration with Center X, the evaluation will collect and/or analyze data generated from classroom logs, classroom observations, measures of pedagogical content knowledge, and measures of teaching attitudes and beliefs, and student academic growth over time if available. The evaluation study has three major goals including providing the STEM+C3 leadership with formative and summative feedback concerning the program's implementation, the evaluation of program goals, and outcomes for program participants. This will be accomplished using the following qualitative and quantitative data sources.

Defining the Study Samples - The primary sample for the evaluation will consist of participants in the STEM+C^3 program over the course of the TQP grant. This will include the 24 participants in mathematics (8 x 3 cohorts) and 24 participants in science (8 x 3 cohorts) who will be recruited and trained by the program. In addition, data will be collected from and analyzed for the 16 to 20 high quality teachers expected to serve as mentor teachers for the novices across the grant. Data will also be collected from the administrators at the high schools in which participants/novices will complete their residencies. In addition, to provide comparative information for the GPRA measures, we will collect data from participants of the other teacher education programs at Center X that are not receiving the statistical thinking and computer science components that are central to the STEM+C^3 goals.

Finally, pending the availability of an adequate sample and district data, student-level data will be collected to examine Question 2f concerning high school student learning. Data for this analysis will be collected for the students of STEM+ C^3 program graduates as well as students

from the graduates of at least one other teacher education program. To create the final analytical samples, a technique such as coarsened exact matching (CEM) will be employed to match data for the STEM+C^3 and comparison group samples. CEM is a flexible matching approach with many favorable properties and allows the specification of precise conditions under which members of comparison and intervention groups can be matched. With this approach, precise cut-points can be set on important prior indicators to ensure that where possible every treatment subject is matched with a suitable comparison (see Iacus, King, & Porro, 2012).

Primary Data Sources

Focus groups and/or interviews. Focus groups and/or interviews will be conducted at UCLA or by phone with novices, mentors, and school administrators as one measure of program implementation. In doing so, we will qualitatively question participants concerning their engagement with the program, the quality of novice and mentor teacher interactions, the role and quality of novice teachers experiences at the partner schools, student participation in the STEM+C^3 courses, and the perceived benefits of participation in the STEM+C^3 community of practice—a forum for novice and mentor teachers to come together to learn, share knowledge, and collaborate that has the goal of creating a sustainable teacher training pipeline in STEM and computer science. Example questions include, but are not limited to: How has your experience in the community of practice supported your development as a STEM and computer science teacher? What are some examples of strategies or activities that you have successfully implemented? What are some examples of how your role as a mentor has been a valuable professional development experience? How has your school's participation in STEM+C^3 impacted student participation in computer science courses?

LOCUS. The Levels of Conceptual Understanding in Statistics (LOCUS) test will be used to measure novices and mentors' baseline and growth in understanding of the key statistical thinking constructs of formulate questions, collect data, analyze data, and interpret results. The assessments were developed and validated through a grant by the National Science Foundation (see Jacobbe, Case, Whitaker, & Foti, 2014) and have been used by CRESST in a past evaluation of a statistical thinking curriculum (IDS) previously developed by Center X.

Observations. Observations will be conducted by Center X of each novice teacher participating in the STEM+C^3 program and data will be analyzed by CRESST. Observers will use a Center X developed rubric to support and understand novice teachers' learning and practices concerning the four dimensions of rigor, discourse, equitable access to content, and classroom ecology. See Nava and colleagues (2018) for information about the validity and reliability of the instrument.

Classroom logs. Novice teachers will be asked to submit online classroom logs at multiple time-points during their residency experience. This will include questions about the primary goals of the lessons, the general and specific instructional strategies and activities used to meet the goals, and the types of questioning and feedback implemented.

Surveys – novices. Novice teachers will be asked to complete online surveys at two time-points. This will include a pre-survey administered at the beginning of their training and a post-survey administered at the end. Surveys at each time-point will be used to measure changes in participant attitudes concerning core program components and philosophies (e.g., statistical thinking, social justice). In addition, on the post-survey attitudes will be assessed concerning the program, coursework, the mentoring and residency components, the community of practice, and their career expectations.

Surveys -- mentors. Teachers who serve as mentors will be asked to complete online surveys at two time-points. The administration will correspond with those for the novices. Surveys at each time-point will be used to measure changes in mentors' attitudes concerning core program components and philosophies (e.g., statistical thinking, social justice). In addition, on the post-survey mentors' attitudes will be assessed concerning the program, their coursework on statistical thinking, the Community of Practice, their mentoring experience, and their future career expectations.

Secondary Data Sources

District and program data. Several measures will be collected by Center X and provided to CRESST concerning regular program processes. This will include data on program enrollment, completion and persistence rates, STEM and computer science certification, master's degree attainment by mentor teachers, teacher demographics and composition, and other program descriptive information consistent with the grant requirements (i.e., GPRA measures).

edTPA. Since the edTPA is a requirement to receive the preliminary teaching credential at all University of California campuses, we plan to draw on it as one measure of whether the STEM+C3 program is meeting its completion goals. Developed and validated by faculty at Stanford University and staff at the Stanford Center for Assessment, Learning, and Equity (SCALE), the edTPA is a subject-specific assessment used to measure skills and competencies that will demonstrate a readiness to teach. This is accomplished through a combination of a portfolio of artifacts, commentaries, and unedited video of candidates' teaching in real classrooms.

CAASPP data. Pending the availability of an adequate sample and the cooperation of the district, California Assessment of Student Performance and Progress (CAASPP) test data will be used to

examine the learning outcomes of students of STEM+ C^3 program graduates as well as students from the graduates of at least one other teacher education program. It should be noted that California only administers the Smarter Balanced tests to high school students in grade eleven and the California Science Test (CAST) once in high school (Grade 10 or Grade 11 depending upon the district).

Data Collection – Table 6 provides an overview of the evaluation questions, data sources, and samples.

Data Analysis Plan

Qualitative data analysis. All interviews and focus groups will be digitally recorded and transcribed. Transcripts as well as observation notes and open-ended survey items will be analyzed by CRESST using qualitative data analysis software. Based on the grounded theory approach (Glaser & Strauss, 1967), data will be analyzed on multiple levels (Miles & Huberman, 1994). At the first level of analysis, we will categorize data according to constructs identified from the STEM+C^3 goals and/or in the literature. At the second level we will compile cases to identify emergent themes by group (e.g., novices, mentors). This will involve the use of constant comparison methods (Strauss & Corbin, 1990) in an iterative process. Finally, at the third level, we will conduct cross-case analyses (e.g., content area, cohort).

Quantitative data analysis. First, the reliability of classroom logs and surveys will be established. This will be done using factor analysis and by calculating Cronbach's alpha to determine whether scales and subscales hold together as single constructs for the different samples.

Table 6. *Matrix of Evaluation Questions, Data Sources, Data Collection Frequency, and Study Samples*

Evaluation sub-questions	Data sources	Frequency	STEM+C^3 group	Comparison group
1. Program Characteristics				
a) Engagement b) Partner site experience c) Community of practice d) Participation in CS courses e) Program benefits	-Interviews/focus groups	Yearly	-Novices -Mentors	
	-Surveys	Twice yearly (pre/post)	-Novices -Mentors	
b) Partner site experience	-Interviews	Yearly	-Administrators	
2. Outcomes: GPRA Measures				
a) Initial certification b) Initial certification in math/science c) One-year persistence d) One-year employment retention e) Three-year employment retention	-Program and district data	Yearly	-Novices	-Novices
f) CS Certification	-edTPA data	Yearly	-Novices	-Novices
g) Student learning	-CAASPP data	End of grant	-Students of grads (new teachers)	-Students of grads (new teachers)
3. Outcomes: Program Foci				
a) Impact on attitudes	-Surveys	Twice yearly (pre/post)	-Novices -Mentors	
b) Impact on statistical thinking fluency	-LOCUS	Twice yearly (pre/post)	-Novices -Mentors	
c) Impact on teaching performance/practice	-Classroom logs -Classroom observations	-1 or more times yearly -1 or more times yearly	-Novices	
d) Mentor certification and master's degree completion	-Program and district data	Yearly	-Mentors	-Mentors

These results will be used to refine the instruments in addition to incorporating the inputs from the program staff. Second, descriptive statistics (e.g., frequencies, means, and standard deviations) will be calculated for quantitative scales derived from classroom logs, classroom observation rubrics, the edTPA, surveys, LOCUS assessment, and the program and district level data that will be used for the GPRA measures and analyses of impact. In addition, simple t-tests

and/or regression analyses will be calculated to compare performance by subgroup for the STEM+C^3 participants (e.g., cohorts, math/science, novice/mentor).

As previously noted, pending an adequate sample and access to data for the analysis of learning outcomes of students taught by completers, a matching technique such as coarsened exact matching will be used to create the final analytical samples. This data will be analyzed using multilevel models to account for the nesting of the data, e.g., students within teachers within teacher education program (Goldstein, 1987; Murray, 1998; Raudenbush & Bryk, 2002). We also anticipate using regression models, which have the advantages of being able to account for the continuous nature of the CAASPP test scores and enables the use of multiple explanatory or independent variables (Sperandei, 2014).