Expanding and Strengthening the STEM Teacher Workforce Through UTeach

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OVERVIEW

The UTeach Institute (Institute), in partnership with four established UTeach programs — The University of Texas at Austin, Louisiana State University, University of Houston, and the University of North Texas — proposes to work in four regions of the country to strengthen STEM and computer science (CS) education. Over three years, in each of the four project regions, we will produce 30 newly certified STEM teachers, including 8CS teachers, who will teach in high-needs schools. We will train another 40 in-service teachers to offer rigorous, project-based, Advanced Placement CS courses. These two goals combined will prepare at least 120 newly certified STEM teachers, including 30 CS teachers, and develop another 160 in-service teachers to implement AP CS courses. If extended to five years, this project will yield 240 new STEM teachers and 320 in-service teachers prepared. Serving the role as external evaluator, the American Institute of Research (AIR) will conduct rapid-cycle continuous improvement studies and an impact study to assess ongoing teacher support as part of the PD and implementation of UTeach CS curricula.

This Supporting Effective Educator Development (SEED) Grant proposal, **Expanding and Strengthening the STEM Teacher Workforce Through UTeach,** addresses Absolute Priority 1, *Supporting Effective Teachers, (1) Providing teachers from nontraditional preparation and certification routes or pathways to serve in traditionally underserved Local Education Agencies (LEAs), (3) Providing teachers with Evidence-Based professional enhancement activities, which may include activities that lead to an advanced credential,* the Competitive Preference Priority, *Promoting Science Technology, Engineering, or Math (STEM) Education, With a Particular Focus on Computer Science,* and the invitational priority*, Support for the use of micro-credentials*.

This project qualifies for a SEED grant, meeting the criteria for moderate evidence for Absolute Priority 1. Two studies, both of which meet WWC standards without reservations, contain relevant overlap of populations and settings with the goals of this project. Granger, Bevis, Saka, & Southerland (2012) examined the efficacy of inquiry-based instructional practices and found that students taught by teachers trained to teach inquiry-based curriculum made significant gains in content knowledge and attitudes toward science compared to students of teachers without the training. Meyers et al (2015) examined the impact of the eMINTS professional development program and found that students taught by teachers who participated in eMINTS scored significantly higher than their control counterparts in math and were found to have higher levels of engagement. A primary focus of the proposed project is preparing teacher candidates and in-service teachers to implement STEM and CS curriculum using inquiry- and project-based instructional approaches. We expect that teachers participating in this project may benefit similarly. In terms of overall program impacts, there is promising evidence that UTeach's approach to preparing highly qualified STEM teachers leads to increased student achievement (Backes, Goldhaber, Cade, Sullivan, & Dodson, in press; Marder & Hamrock, 2016).

A. PROJECT DESIGN

A.1. UTeach STEM Teacher Development – Exceptional Approaches

The Institute, housed at the University of Texas at Austin, supports the national expansion of UTeach, a nationally recognized, non-traditional, university-based secondary science, technology, engineering, and mathematics (STEM) teacher preparation program. UTeach operates at 44 universities (Appendix A: National UTeach Map) and has produced nearly 4,500 STEM teachers, 70% of whom teach in high-needs schools. Eighty percent of UTeach graduates who enter teaching are retained at the five-year mark (UTeach Institute, 2018). The Institute is also home to the UTeach CS initiative, launched in 2015. More than 460 teachers have been trained to teach the College Board–endorsed (College Board, 2016), *UTeach CS Principles* curriculum in the last two years and another 175 teachers will be trained during the summer of 2018. Through these two initiatives, UTeach is making a significant contribution to addressing the STEM teacher shortage (See Section "Significance"). This proposal provides an exceptional approach to increasing the number of educators in high-needs schools adequately prepared to deliver rigorous instruction in STEM fields, including CS, through two Project Goals.

Project Goal 1: To increase the number of highly qualified STEM teachers in high-needs schools through the strategic expansion of UTeach preparation pathways. This project will expand UTeach program pathways at four UTeach programs to develop a post-baccalaureate, alternative route to prepare new STEM graduates, career-changers, returning military, and other degree-holders to become STEM teachers who will bring inquiry- and project-based teaching methods to high-needs secondary schools. This work will increase the number of highly qualified STEM teachers, including the preparation of CS teachers (*Absolute Priority 1 and Competitive Preference Priority*).

Project Goal 2: To increase the number of computer science teachers who can broaden participation of underrepresented students in computer science in high-needs schools through evidence-based professional development of in-service teachers. The Institute will create a two-year sequence of project-based, AP CS curricula by developing one new project-based, high school AP CS A curriculum offering to accompany our current AP CS Principles curriculum, *UTeach CS Principles*. We will prepare in-service teachers, from CS and other backgrounds, to offer the current AP CS Principles course using the College Board–endorsed *UTeach CS Principles* curriculum and teacher support model. We will also prepare in-service teachers to offer a new, project-based AP CS A course curriculum, *UTeach CS A*. Additionally, we will develop a series of UTeach CS Teaching micro-credentials based on this work (*invitational priority*). This work will increase the number of high school teachers qualified to offer rigorous CS coursework (*Absolute Priority 1 and Competitive Preference Priority 1*).

This project builds on (1) the UTeach STEM teacher preparation model; (2) the expertise of the Institute; (3) the project-based, *UTeach CS Principles* curriculum; and (4) the UTeach CS teacher development and support model, to improve STEM, including CS, instruction in high-needs schools in the four project regions.

***The UTeach STEM teacher preparation model*.** The UTeach program offers an effective model of teacher preparation that is specialized for the preparation of STEM teachers. As such, it draws equally on research in STEM disciplines and on STEM teaching and learning. Inquiry and project-based learning are foundational to the preparation model. It calls for pairing research and clinical faculty and relies heavily on early, intensive, ongoing, and highly supported clinical teaching throughout preparation (Appendix B: UTeach Elements of Success).

UTeach has been shown to be effective as demonstrated by two recent studies in Texas showing significant learning gains in mathematics and science by students of UTeach teachers when compared with students of non-UTeach teachers. In Backes et al. (2016), researchers found that secondary students taught by UTeach graduates outperformed all students in the state by an additional 4 months of learning in math and 5.7 months in science over the course of one academic year. In a second study, Marder and Hamrock (2016) found that secondary students taught by UTeach graduates gain an additional 9 months of schooling in both Algebra I and Biology for Gifted students and 5 months of learning in Biology for economically disadvantaged and Latino/a students. Combined, these studies demonstrate that UTeach teachers in Texas are more effective overall and with diverse, high-needs populations.

This project proposes to expand UTeach preparation to a population not previously served by UTeach—STEM degree-holders, career-changers, and returning military. The same preparation approach and curriculum will be customized to meet the needs of these post-baccalaureate candidates. The foundation of inquiry- and project-based instructional approaches in UTeach also informs the development of K–12 CS curriculum, and our approach to developing in-service teachers' classroom instructional skills to engage historically underrepresented students in CS.

***The expertise of the UTeach Institute*.** The Institute maintains a well-established approach to developing and scaling education programs (Beth, Hughes, Romero, Walker, & Dodson, 2011) that is aligned with recommendations from the research literature on fidelity of implementation, program replication, expansion and evaluation, and networked improvement, and includes clear articulation of program elements, comprehensive planning, intensive implementation support, monitoring of progress, and long-term sustainability through community engagement and continuous, networked improvement (Century, Rudnick, & Freeman , 2010; Hall & Hord, 2010; Hill, Maucione, & Hood, 2007; Bryk, Gomez, & Grunow, 2011; Patton, 2011).

Significant effort has been invested in establishing and supporting a networked improvement community (NIC) (Bryk, Gomez, Grunow, & LeMahieu, 2015; Christie, Inkelas & Lemire, 2017) of university faculty, administrators, and staff that provides a framework for collaborative development, testing, and improvement over time of the UTeach model. The Institute has applied the same approach to the development, implementation, and evaluation of the nationwide UTeach CS initiative and we have similarly built a network of more than 450 classroom teachers all implementing the *UTeach CS Principles* curriculum. The Institute serves as the hub for both these NICs and will coordinate the proposed work for this project.

The project-based AP CS Principles curriculum, UTeach CS Principles. Developed at UT Austin beginning in 2013, *UTeach CS Principles* is a National Science Foundation-supported (NSF awards #1138506, #1441009, and #1543014), project-based, AP CS Principles curriculum and professional development (PD) program that was among the first five AP CS Principles curricula and PD programs officially endorsed by the College Board in 2016, with AP CS Principles Framework alignment verified by Learning List (2017). The curriculum is designed explicitly to broaden participation in computing by engaging females and other historically underrepresented students by providing a broad introduction to CS early in their high school careers. AP CS Principles calls for a multidisciplinary approach to teaching seven Big Ideas and six Computational Thinking Approaches) that comprise the fundamental principles ofCS. There is also an emphasis on creative problem-solving and self-expression (College Board, 2016).

The 2016-17 school year marked the first administration of the College Board's AP CS Principles exam. Overall, results for students enrolled in *UTeach CS Principles* were strong. Analysis conducted by Marder (2017) show that 83% of students in *UTeach CS Principles* passed the exam—earning a score of at least 3 out of 5—versus 74% in the nation. Results for female students were also positive, performing on par with their male counterparts (83% vs 82%). While performance among Black and Latino/a students was 55% and 70% passing, these scores were significantly higher than the general AP CS Principles passing rate of 42% and 57% , respectively. Most notably, these differences in pass rates remained significant after accounting for effects from students' economic status, race, and ethnicity in the *UTeach CS Principles* course population compared with the national population (Marder, 2017).

This project will utilize the same processes used to develop the *UTeach CS Principles* curriculum to develop a new, project-based *UTeach CS A* curriculum. Like *UTeach CS Principles*, the foundation for this new course will be project-based instructional strategies designed to engage underrepresented students in CS. Development of the UTeach CS A curriculum will be supported by matching funds provided by the UTeach Institute.

UTeach Computer Science teacher development and implementation support model. The *UTeach CS Principles* teacher development and support program has been successfully implemented with more than 460 teachers (with a variety of disciplinary backgrounds) through Summer 2017 (Burd, 2017). We expect to train another 175 teachers during Summer 2018. The program includes 40 hours of in-person or online teacher professional development focused on implementing the *UTeach CS Principles* course content, project-based instructional approaches, student learning and assessment, and College Board AP requirements. Supplemental professiona learning content is also available in the form of online UTeach CS modules on project-based learning (PBL); Scratch and Processing programming languages; and discrete mathematics. The curriculum includes student-facing content and comprehensive teacher materials. UTeach teach support specialists provide year-long, on-demand implementation support.

We propose to develop comprehensive teacher support materials to accompany the *UTeach CS A* curriculum. We will also develop a 40-hour teacher professional learning workshop devoted to course content, project-based instructional strategies, and College Board AP requirements. We will provide professional development and implementation support provided by dedicated teacher support specialists to in-service teachers from a variety of backgrounds to implement the project-based *UTeach CS Principles* and *UTeach CS A* curricula.

This proposed project represents an exceptional approach to the proposal priorities in that it (1) builds on extensive experience and successful results achieved by UTeach for both STEM teacher preparation and in-service CS teacher preparation, (2) relies on rigorous, research-based instructional approaches involving inquiry- and project-based learning to engage historically underrepresented students in STEM, and (3) proposes to work intens ively in four regions to prepare both pre-service and in-service teachers to strengthen STEM, including CS, instruction in high-needs schools. A project logic model is included in Appendix C.

A.2. Improving STEM instructional practices through UTeach pre-service and in-service teacher development

Both the UTeach teacher preparation program and the UTeach CS initiative are founded on

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To accomplish Goal 1, wewill expand the UTeach STEM teacher preparation model to include a

Candidate preparation. The Institute will develop, in collaboration with our UTeach program partners, a one-year, streamlined program of coursework and clinical teaching experiences that will qualify candidates to enter the classroom as a teacher of record with a probationary certificate. In Texas, this first year of teaching with a probationary certificate is referred to as the Internship year. During this Internship year, UTeach Master Teacher clinical faculty will support candidate development through in-person coaching, mentoring, and targeted improvement.

The post-bac pathway will continue to be characterized by rigorous content preparation combined with a clinically intensive UTeach curriculum that is firmly situated within the STEM domains, combining relevant content, intensive teaching opportunities, and extensive individualized coaching to develop candidates' knowledge and skills at an accelerated rate. Rather than offer stand-alone courses, important topics, including instructional technology, assessment, and equity and special populations, are embedded into all UTeach courses. Furthermore, STEM content- and discipline-specific pedagogy will be integrated throughout the UTeach curriculum, emphasizing the underlying connections between mathematics and science.

The proposed post-bac pathway will be well aligned with current standards-reform initiatives, including the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS), which place an increased emphasis on developing depth of discipline-specific content knowledge and conceptual understanding; building skills in science, mathematical, and engineering practices; and applying science and mathematics to solve authentic problems. This in turn necessitates the preparation of teachers with deep content knowledge who have experience designing, carrying out, analyzing, and presenting independent scientific inquiries; constructing and defending logic-based mathematical arguments; applying mathematical tools and practices to solve complex problems and model scientific phenomena;

and designing problem- and project-based learning environments for all learners. These are all

A two-semester course sequence will include 16–19 credit hours of UTeach coursework and allows for 8–14 hours of content coursework. In our experience at UT Austin, many STEM degree holders require a limited number of content courses in order to be fully qualified to teach their desired STEM subject and research suggests that teachers with strong content knowledge are more successful in promoting student learning (Hill, Rowan, & Ball, 2005). Required UTeach coursework includes *Inquiry Approaches to Teaching and Lesson Design* (2 credits); *Knowing and Learning in Mathematics and Science* (3 credits); *Perspectives on Science and Mathematics* (3 credits); *Functions and Modeling* (Math only—3 credits); *Research Methods* (3 credits); and *Classroom Interactions & Project-Based Instruction* (5 credits).

In addition to coursework and field teaching, candidates will provide evidence through a portfolio and teaching observations that they are proficient across a number of competencies ranging from subject-matter knowledge to effective instructional design and classroom management. This collection of evidence must satisfy minimum criteria in order for a candidate to be recommended for probationary certification and an Internship year as teacher of record.

Candidate Teaching and Induction Support. The UTeach preparation model calls for early, intensive, and highly supported clinical teaching (Urban Teacher Residency United, 2015) throughout the program, followed by comprehensive induction support. Combining clinical practice with strong coaching and mentoring during preparation, and then providing ongoing induction support, are critical components of the UTeach model and well-supported by research (Humphrey & Wechsler, 2007; Moir, 2009). Strong partnerships between UTeach programs and local school districts will ensure that the alternative routes developed meet local needs. Local school and district leaders will serve as members of UTeach program steering committees.

UTeach Master Teacher clinical faculty are former secondary STEM teacher leaders who are hired by UTeach programs to provide full-time clinical teaching support and instruction to students. They are paired with STEM education research faculty to co-teach courses and they assume primary responsibility for arranging field teaching placements, assisting students with field preparation, observing and evaluating student field teaching, and providing induction support. Candidates will complete approximately 40 hours of field teaching over two semesters in preparation for their Internship year as teacher of record. All field placements will take place in high-needs schools. Competencies required for recommendation for probationary certification are outlined in the UTeach Portfolio assessment and the UTeach Observation Protocol (UTOP), a validated classroom observation instrument (Walkington & Marder, 2014) (See Appendix D).

Upon completion of all coursework, field teaching, portfolio requirements, and state-required testing, candidates will be recommended for probationary certification and hired as a teacher of record for an Internship year in a high-needs school. Candidate support will continue throughout the Internship year. UTeach Master Teacher clinical faculty will provide intensive instructional coaching and conduct a series of observations of teaching using the UTOP. Candidates will also attend in-person professional development sessions tailored to their needs. By the end of the Internship year, candidates will become fully certified.On-demand support will continue to be available through email, classroom visits, materials lending, and lesson development support throughout their second year in the classroom as teacher of record.

Thoughtful adaptation of the UTeach STEM teacher preparation model as a post-baccalaureate, alternative route customized to meet the needs of career-changers, returning military, and other degree-holders will ensure the successful preparation of STEM teachers for high-needs classrooms. Robust candidate recruitment and careful candidate selection, combined with rigorous, research-based instruction in STEM and STEM teaching and learning; and early, intensive, and highly supported clinical teaching and induction support will prepare candidates to successfully demonstrate required competencies in order to be recommended for initial probationary certification and to ultimately achieve full teaching certification.

Goal 2: Increase the number of computer science teachers who can broaden participation of underrepresented students in computer science in high-needs schools through evidence-based professional development of in-service teachers.

This work also relies heavily on the role of project-based instruction on differentiating learning. Project-based learning (PBL) centers on authentic tasks but is distinguished from other forms of inductive learning by its focus on the creation of a product as a driver for learning (Prince & Felder, 2006). Barron et al. (1998) described four design principles for PBL: (1)

defining learning-appropriate goals that lead to deep understanding, (2) providing scaffolds, (3) providing opportunities for self-assessment and revision, and (4) developing social structures that promote participation and a sense of agency. Developed as a project-based course, *UTeach CS Principles* includes each of these components as refined through six years of implementation and teacher feedback (Veletsianos, Beth, Lin, & Russell, 2016).

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one, student-facing course content and accompanying teacher lesson guides will be developed and in year two, the new course will be piloted and revised. A first version of the new course will be released in summer 2020. We are not requesting grant funds for course development and all costs associated with development are being applied to the required project funding match.

Teacher professional learning competencies and content development. Beginning in year one, we will partner with Digital Promise to develop up to ten UTeach CS Teaching micro-credentials

CS content, computational thinking practices, equity and inclusive teaching, and project-based instructional strategies. We will follow a well-defined process developed by Digital Promise to outline competencies, develop assessment rubrics, identify artifacts to be collected, and design, produce, and host the micro-credentials on their platform. Over a three-year period, we will work to calibrate assessments, refine competencies and credentials, and deploy final micro-credentials .

In year two, we will develop 40 hours of teacher professional learning around the *UTeach CS A* curriculum, project-based instructional strategies, and College Board AP course requirements. Our approach to teacher professional learning and support has been heavily informed by recommendations made by the Center for Elementary Mathematics and Science Education in its Landmark Study of CS professional development offerings (2013)—including the use of small-group discussion and providing opportunities for teacher reflection. Our approach further includesresearch-based pedagogical strategies endemic to CS teaching (e.g., collaboration through pair programming) in order to engage diverse student populations (Alvarado & Dodds, 2010; Ho, Slaten, Williams, & Berenson, 2004; Simon & Hanks, 2008). Additionally, considerable time is devoted to modeling the PBL pedagogy underpinning the curriculum. Teachers experience the course from the point of view of a student, engaging with

Teacher professional development and ongoing implementation support. In project year one, high-needs schools in the four project regions will be identified to expand CS course offerings by introducing AP CS Principles. Schools participating in the project will receive all curriculum materials and training at no cost to them. Teachers will be recruited to receive *UTeach CS Principles* course training either in-person or online during Summer 2019 and will receive $1,000 stipends. Beginning in Summer 2020, the same process will be followed to offer training for the new *UTeach CS A* curriculum. Over the course of three years, a total of 160 teachers will be trained. During training, all teachers will be enrolled in an online professional learning community where they can share best practices, ask questions, and receive peer feedback and support. This online community is fully facilitated by two UTeach CS Teacher Support Specialists. These same teacher support specialists are available via phone, email, and virtual office hours to provide on-demand support for teachers and they regularly host topical course implementation webinars throughout the year.

Expansion of project-based, UTeach CS curricula, along with evidence-based, high-quality teacher development and support, will effectively expand CS course offerings and engage a more diverse group of students in high-needs schools in CS in the four project regions.

A.3 Leveraging Existing Partnerships

The project brings together four well-established UTeach partners with the capacity to expand their local UTeach programs to add a post-baccalaureate, alternative certification pathway. Annually, the four UTeach partner programs produce an average of 147 graduates, 70% of whom teach in high-needs schools: Louisiana State University—*GeauxTeach* (20); University of

Houston—*teachHOUSTON* (35); University of North Texas—*Teach North Texas* (37); and University of Texas at Austin—*UTeach* (55). All programs are located in urban regions with persistent shortages of STEM teachers (see section A.4). These partners are highly qualified to contribute to the required course redesign to develop the proposed alternative certification route. Each partner UTeach program has well-established relationships with surrounding high-needs public school districts and these partner districts have expressed their support for this project (see letters of support). As a result of this project, we expect each partner to diversify their enrollment and increase their production of STEM teachers by approximately 20%.

Through our partnership with Digital Promise (see Appendix F Letters of Support), we will develop a series of UTeach CS Teaching micro-credentials. Digital Promise provides a comprehensive and well-established approach to the development of micro-credentials and provides a robust digital platform for hosting and awarding of micro-credentials.

The American Institutes for Research brings more than 70 years of experience in behavioral and social science research and evaluation to this project and is particularly well-suited to carry out the evaluation and research components of this project.

A.4. Targeting High-needs Schools and Students

UTeach has always prioritized the preparation of a diverse STEM teaching workforce prepared to serve in high-needs schools with diverse student populations. Situated in four urban regions in Texas and Louisiana—Austin, Baton Rouge, Denton/Dallas/Fort Worth Metroplex, and Houston—all project partners have strong partnerships with diverse, high-needs school districts Table 1 provides a list of school district partners.

Table 1: School District Partner Pool

University	School District Partner Pool
Louisiana State University	Ascension PSS, Baker System, Central System, East Baton Rouge PSS, Ibberville PSS, Livingston System, West Baton Rouge PSS, Zachary System

University of Houston	Spring Branch ISD, Fort Bend ISD, Houston ISD, Pasadena ISD
University of North Texas	Fort Worth ISD, Dallas ISD, Denton ISD, Lewisville ISD, McKinney ISD, Coppell ISD, Irving ISD
University of Texas at Austin	Austin ISD, Del Valle ISD, Manor ISD, Leander ISD, Round Rock ISD, Pflugerville ISD

Table 2 shows that these districts include more than 800 school-wide Title 1 schools with 69% of the students in these districts identified as underrepresented minoritiesFifty-three percent of students in these districts are economically disadvantaged. None of these regions had more than six percent of high school students enrolled in anyCS course during 2016-17.

Table 2: Selected School District Characteristics

Geographic Region	*Number of School-Wide Title 1 Schools*	*Percent Underrepresented Minorities*	*Economically Disadvantaged Students*	*Students Enrolled in Computer Science*
Louisiana Region				
Baton Rouge (8 Systems)	168	55%	59%	5%
Texas Regions				
Austin (6 Districts)	154	64%	52%	6%
Houston (4 Districts)	387	81%	61%	4%
Dallas/Fort Worth Metroplex (7 Districts)	453	70%	88%	5%

Source: Texas Education Agency, 2017. Louisiana Department of Education, 2017. National Center for Education Statistics, 2017.

This project also addresses the lack of diversification in the teacher workforce and persistent STEM teacher shortages (Albert Shanker Institute, 2015). School districts continue to report having to hire unqualified teachers (Bailey, 2017). In Texas, 16% of middle and high school math teachers are notcertified to teach mathematics, and 31% of science, technology, and CS teachers are not certified to teach these subject areas (Texas Education Agency, 2017) . In Louisiana, 41% of economically disadvantaged students in Title 1 schools are taught by teachers out of field or without certification (Louisiana Department of Education, 2017). All post-bac, alt-cert candidates will be placed in high-needs schools for all field teaching experiences. They will be required to obtain their first-year teaching internship in a high-needs school as well.

A.5. Addressing the Needs of High-needs Students

This project will address the needs of high-needs students by increasing (1) the number and

Studies indicate that alternative certification routes attract a more diverse pool of candidates, including greater numbers of career changers and minorities (Education Alliance, 2008; Klagholz, 2000; Shen, 1998; Rowland Woods, 2016). In addition to increasing the number of STEM teachers, we expect to produce more minority STEM teachers for high-needs schools.

Through development of in-service teachers to implement project-based CS curriculum, we are specifically addressing the lack of representation in CS among female and other historically underrepresented students. In addition to strengthening student-centered instructional approaches that engage learners in solving problems relevant to their community (Marshall & Alston, 2014), UTeach CS curricula directly address stereotype threat with students, acknowledge student identity in the classroom (Steele & Cohn-Vargas, 2014), provide successful minority exemplars in STEM, and affirm student values (Cohen & Sherman, 2014).

Both the UTeach preparation program and the UTeach CS initiative are founded on evidence-based, inquiry- and project-based instructional approaches and student-centered learning environments described in detail in section A.2 (Boaler, 2002; Krajcik et al., 1998; Marshall & Alston, 2014; Marshall, Petrosino, & Martin, 2010; Ali, 2005; Barg, et al., 2000; Fee & Holland-Minkley, 2010; Polanco, Calderón, & Delgado, 2004; Varma, 2006) . Specifically, the UTeach approach relies on rigorous, research-based instructional approaches involving inquiry-and project-based learning to engage historically underrepresented students in STEM. Furthermore, the studies described in sectionA.1 demonstrate that UTeach teachers are more effective overall and with diverse, high-needs students.

B. SIGNIFICANCE

B.1 National Impact

There were nearly 8.6 million STEM jobs in May 2015, representing 6.2% of U.S. employment and, of those jobs, computing occupations made up nearly 45% of STEM employment (Fayer, Lacey, & Watson, 2017). Most of the largest STEM occupations were related to computers and information systems (Fayer, Lacey, & Watson, 2017). This increase in demand for STEM workers and CS in particular justify the importance and magnitude of results that are likely to be attained by increasing the number of STEM teachers and providing critical supports for their continued professional development.

The importance of the outcomes likely to be attained by this project can be characterized by: (1) the number of teachers and students impacted, (2) the specific attained outcomes for high-needs students, and (3) the extent to which the study and results obtained would determine the effectiveness of this project and have implications for future work. Nationally, UTeach has already made significant strides toward addressing the national STEM teacher shortage by establishing permanent university programs that have increased STEM teacher production. According to U.S. Department of Education Title II teacher preparation data (2016),

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Project Goal 1 will increase the number and diversity of STEM teachers prepared in four regions by creating new, permanent alternative post-baccalaureate routes to secondary STEM teaching certification and targeting underrepresented degree holders, including career changers and veterans. We expect to prepare a total of 120 new STEM teachers (30 per UTeach program site) over three years (240 over five years if extended) , including 30 fully certifiedCS teachers (60 in five years), expanding current annual STEM teacher production by 20% at partner programs.

Project Goal 2 will prepare 160 in-service teachers to broaden participation by female and other historically underrepresented students in CS by increasing access to engaging, project-based CS curriculum and preparing more in-service teachers to effectively teach CS . In 2013, the U.S. Department of Commerce found that only 7% of computing positions were held by African Americans, and 6% were held by Latino/as (Landivar, 2013). These imbalances ensure limitations to innovation (Lehman Brothers Center for Women in Business, 2007). The historic launch of the College Board's AP CS Principles course in 2016-17 suggests that curriculum reform and teacher professional development and support has the potential to significantly impact these trends. In just one year, the numbers of female, Latino/a, and African American students enrolled in CS-related AP courses all doubled. Passing rates also doubled for female students and tripled for Latino/a and African American students (College Board, 2017). Despite these successes, however, there is work to be done. Across Texas, participation in AP CS coursework by females (29%), Latino/a (31%), and African American (4%) students was well below their overall shares in school enrollment (50%, 52%, 13%). Excepting Latino/a students, the same is true for Louisiana: students participating vs. enrollment were 30% vs. 50% for females, 8% vs. 9% for Latino/as, and 20% vs. 46% for African Americans (Ericson, 2017). There are also significant achievement gaps,with White and Asian students passing at rates at least double those of their underrepresented minority counterparts who took AP CS exams in

2017 (College Board, 2017). This project will significantly improve participation and achievement of underrepresented students in rigorous CS courses across the four project regions.

The continuous improvement evaluation and impact research studies conduct by the Institute and AIR will yield findings that will further our understanding of how best to prepare STEM teachers from a post-baccalaureate population of candidates. These studies will also provide insights into the role that project-based curriculum and teacher support play in implementation and student engagement and learning outcomes in CS.

B.2 Cost Effectiveness

If funded, this project will permanently establish new alternative STEM teacher preparation pathways at UTeach programs and prepare 280 STEM teachers who will impact approximately 28,000 high-needs high school students. Of those teachers prepared, 120 will be newly prepared STEM teachers, of whom 30 will be CS teachers. A new, project-based AP CS A curriculum will be developed and another 160 in-service teachers from a variety of backgrounds will be prepared to offer two rigorous CS courses. The total funding three-year request this project is $4,578,952. The total project cost, including matching funds, is $6,675.365 over three years. If extended to five years, 560 STEM teachers will be prepared, 240 new STEM teachers and 320 in-service teachers for a five-year project cost of $11,696,610.

UTeach is a cost-effective model that leverages the university infrastructure. Funding the expansion of four existing UTeach programs also leverages the UTeach program infrastructure already in place to significantly increase teacher production with a minimal investment. Once established, the new program pathways will continue enrolling and preparing teachers in perpetuity. These high-quality STEM teachers will enter high-needs schools and help their students to be successful in STEM subjects. This is perhaps the biggest return on investment, as our nation's economy depends on a strong STEM workforce. We will need approximately one million new STEM workers—34% more than are currently produced—over the next decade to remain internationally competitive (Xue & Larson, 2015). Preparing a more effective and diverse STEM teaching workforce is vital to preparing more students to successfully pursue STEM careers. Given the economic and labor imperatives, the aforementioned teacher shortages, and the demand for STEM workers and computer scientists in order for the US to remain globally competitive, the cost of *not* doing this work is an important consideration.

B.3 Sustaining Project Activities and Outcomes

The goals for this project have been specifically designed based upon proven and scalable approaches that have the potential to continue beyond the life of the grant period. Coburn (2003) and Dede and Rockman (2007) have outlined several interrelated dimensions as best practices for scaling and sustaining the types of educational innovations outlined in this proposal. These dimensions include depth, spread, shift, sustainability (Coburn, 2003) and evolution (Dede & Rockman, 2007) and inform the Institute's approach to program development and expansion.

Once established, UTeach alternative route program pathways will be sustained in perpetuity, leveraging existing university and program infrastructure. In fact, given the nature of the national UTeach network, we expect additional UTeach programs to adopt the UTeach post-baccalaureate, alternative pathway based on the model developed through this project. UTeach CS curriculum and teacher professional development will continue to be made available to schools and teachers nationwide as well. The Institute offers a competitive pricing and support structure that has been in place for three years and is scalable and sustainable.

B.4. Disseminating Project Findings

As a result of this project, we will publish white papers describing the lessons learned and successful strategies for recruiting and supporting diverse and underrepresented students into the STEM teaching profession through UTeach. The UTeach conference provides an annual opportunity for UTeach program stakeholders to share research and innovations. Institute staff and faculty from each of the participating programs will present information about or findings from this project at a minimum of one conference by project year three.

The Institute will publish all documentation related to the UTeach alternate, post-bac STEM teacher preparation pathway so that all 44 current UTeach programs might adopt and implement it. Further, findings will be disseminated in reports and presentations annually at regional and national CS and broader educational conferences and meetings; and in peer-reviewed journals and conference proceedings. The Institute will also work with the CS Teachers Association (CSTA), the CSforAll consortium, and CS for All Teachers, to disseminate project findings via established online communications and publications.

C. MANAGEMENT PLAN

C.1. Project Goals, Activities, Objectives, and Outcomes

Project Goal 1: To increase the number of highly qualified STEM teachers in high-needs schools through the strategic expansion of UTeach preparation pathways.

Goals and objectives. Our goal of increasing the number of highly qualified STEM teachers in high-needs schools will be accomplished by achieving the following objectives: (1) Expansion o the current UTeach STEM teacher preparation program model to include a post-baccalaureate , alternative route to STEM teacher preparation; (2) Development of strong, collaborative partnerships between university-based UTeach programs and local high-need LEAs; (3) Recruitment and selection of candidates from new STEM graduates, career changers, returning military, and other degree holders, prioritizing CS; (4) Preparation of STEM teaching candidates to bring inquiry- and project-based teaching methods to high-needs schools through rigorous, research-based coursework and intensive clinical teaching support; (5) Placement of teaching candidates in high-needs schools; (6) Provision of ongoing induction support for STEM teaching alumni; (7) Development and dissemination of program materials and operational and instructional resources to additional UTeach programs nationwide.

Outcomes. We expect the following outcomes as a result of this work: (1) UTeach post-bac, alt-cert STEM teacher preparation pathways will be established at four UTeach programs; (2) 120 new STEM teachers, including 30CS teachers, will be produced and fully certified; (3) UTeach STEM teacher preparation course curricula and clinical teaching support will be streamlined, updated, and customized for this new, post-bac pathway to meet the unique needs of teaching candidates selected and of partner LEAs; (4) High-quality candidates will be recruited and selected; (5) UTeach post-bac teaching candidates will be placed in high need schools, impacting approximately 18,000 students over the course of the project; (6) Partnerships between UTeach program sites and high-need LEAs will be strengthened as teacher preparation and support is customized to specifically address the needs of local schools and districts; (7) Insights will be developed into how best to prepare STEM teachers from a post-baccalaureate population of candidates; and (8) Additional UTeach programs will be expanded by adopting and implementing the UTeach post-bac, alt-cert STEM teacher preparation pathway.

Project Goal 2: Increase the number of computer science teachers who can broaden participation of underrepresented students in computer science in high- needs schools through evidence-based professional development of in-service teachers.

Goals and objectives. Our goal of increasing the number of CS teachers prepared to broaden participation of underrepresented students in CS in high-needs schools will be accomplished by achieving the following objectives: (1) Development of a new project-based, high school CS courses to create a two-year sequence of UTeach, project-based, AP CS courses; (2) Preparation of in-service teachers, from CS and other disciplinary backgrounds, to teach the AP CS Principles course using the College Board–endorsed, project-based, *UTeach CS Principles* curriculum; (3) Preparation of in-service teachers to teach a new, project-based *UTeach CS A* course; and (4) Provision of year-long, on-demand, course implementation support.

Outcomes. We expect the following three-year outcomes as a result of this work: (1) 160 high school teachers will implement UTeach CS course curricula in four project regions; (2) the number of underrepresented students enrolled in CS courses will increase in four project regions; (3) teacher confidence and skill implementing project-based learning instructional strategies will increase; and (4) we will gain insights into the role that project-based curriculum and teacher support play in implementation and student engagement and learning outcomes in CS.

Project Activities

Timeline and activities for Goal 1: To increase the number of highly qualified STEM teachers in high-needs schools through the strategic expansion of UTeach preparation pathways. Based on the project design described in previous sections , we propose five primary activities to accomplish Goal 1: 1) comprehensive planning and development for program expansion, 2) implementation support, 3) ongoing monitoring and evaluation, 4) development of expansion materials, resources, guides, and curriculum, and 5) comprehensive induction support for program graduates. All activities will be overseen by the Director and Associate Director of the Institute. Additional staff responsible are identified in Table 3.

Table 3. Goal 1: Timeline and Activities for															
	Formal Project Period									**Extension Period**					
	2018	2019			2020			2021		2021	2022		2023		
Fall=F; S=Spring; Summer=SU	F	S	Su	F	S	Su	F	S	Su	F	S	Su	F	S	Su
1. Comprehensive planning for UTeach pathways expansion *Institute Staff: Director, Associate Director, Manager of Content and Communications, Instructional Designer* *Partner Program Staff: Co-Directors, Program Coordinator*															
1.1 Convene program co-directors for two-day program launch workshop	X														
1.3 Finalize re-designed curriculum	X	X	X												
1.4 Develop candidate selection & recruitment materials, & regional recruitment campaigns	X	X													
1.5 Partner programs establish steering committee of key stakeholders; hire faculty & staff; develop degree plan pathways; develop program materials; recruit and select candidates; obtain university and state program approval	X	X	X												
2. UTeach program expansion implementation support *Institute Staff: Director, Associate Director, Manager of Site Support, Site Coordinator* *Partner Program Staff: Co-Directors, Program Coordinator, Master Teacher Clinical Faculty, Research Faculty*															
2.1 Provide on-demand technical assistance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.2 Provide course training workshops		X			X			X			X			X	
2.3 Conduct one-day site visit				X	X		X	X			X			X	
2.4 Convene partners at annual UTeach conf			X			X			X			X			X
2.5 Partner programs convene steering committee		X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.6 Partner programs enroll candidates				X			X			X			X		
2.7 Partner programs provide individualized advising and targeted student support				X	X	X	X	X	X	X	X	X	X	X	X
3. Ongoing monitoring and data collection (See Section D: Project Evaluation)															
4. Development of expansion materials, resources, guides, and curriculum content *Institute Staff: Director, Manager for Content and Communications, Instructional Designer*															
4.1 Develop, publish & update UTeach post-bac program candidate recruitment and selection manual		X		X			X			X			X		

4.2 Develop, publish, and regularly update UTeach post-bac program Clinical Internship support manual			X			X			X			X			X
4.3 Develop and publish UTeach post-baccalaureate program course activities/innovations/adaptations							X			X			X		
4.4 Develop and publish UTeach post-bac program operations manual			X		X			X			X			X	
5. Comprehensive induction support for program graduates *Institute Staff: Associate Director, Associate Director for K-12 Initiatives, Alumni Member Services and Communications Coordinator, Data and Evaluation Coordinator* *Partner Program Staff: Co-Directors, Program Coordinator, Master Teacher Clinical Faculty*															
5.1 Induct grads into UTeach Alumni network								X			X			X	
5.2 Alumni employment tracked and reported											X			X	
5.3 Ongoing, on-demand support provided to alumni via UTeach Alumni network website								X	X	X	X	X	X	X	X
5.4 UTech Alumni conference held						X			X			X			X
5.5 Partner programs design and implement local induction support									X	X	X	X	X	X	X

Timeline, tasks, and activities for Goal 2: Increase the number of computer science teachers who can broaden participation of underrepresented students in computer science in high-needs schools through evidence-based professional development of in-service teachers. Based on the project design described in previous sections, we will prepare high school in-service teachers from CS and other disciplinary backgrounds to teach two rigorous, project-based, AP CS courses—*UTeach CS Principles* and *UTeach CS A*. Three primary activities will accomplish Goal 2: 1) Develop UTeach CS professional learning competencies and coursework, 2) Provide UTeach CS teacher professional development, 3) Provide ongoing teacher implementation support. The Director of the Institute will oversee all activities. Additional staff responsible are identified in Table 4.

Table 4. Goal 2: Timeline and Activities		
	Formal Project Period	**Extension Period**

	2018	2019			2020			2021		2021	2022		2023		
Fall=F; S=Spring; Summer=SU	F	S	Su	F	S	Su	F	F	S	Su	F	S	Su	F	F
1. Develop computer science teacher professional learning competencies & coursework *Institute Staff: Associate Director for K-12 Initiatives, Manager of UTeach Computer Science, Instructional Designer*															
1.1 Develop, test, refine high school teacher CS competencies and micro-credentials	X	X	X	X	X	X	X	X							
1.2 Award teacher micro-credentials					X	X	X	X	X	X	X	X	X	X	X
1.3 Develop, publish, and update high school project-based AP CS A course and teacher materials	X	X	X		X			X			X			X	
1.4 Pilot high school AP CS A course				X	X										
1.5 Develop, publish, and annually update AP CS A teacher professional development coursework					X			X			X			X	
2. Provide UTeach Computer Science teacher professional development *Staff: Associate Director for K-12 Initiatives, Manager of UTeach Computer Science, UTeach CS Teacher Support Specialists*															
2.1 Conduct AP CS Principles teacher PD			X			X			X			X			X
2.2 Conduct AP CS A teacher PD						X			X			X			X
3. Provide on-going, on-demand, teacher implementation support *Staff: Manager of UTeach Computer Science, UTeach CS Teacher Support Specialists*															
3.1 Support teachers in online professional learning community			X	X	X	X	X	X	X	X	X	X	X	X	X
3.2 Provide on-demand support via phone, email, & virtual office hours			X	X	X	X	X	X	X	X	X	X	X	X	X
3.3 Provide regularly scheduled, topical support webinars			X	X	X	X	X	X	X	X	X	X	X	X	X
4. Ongoing monitoring and data collection (See Section D: Project Evaluation)															

C. 2. Organizational Capacity and Adequacy of Management Plan

Housed at The University of Texas at Austin, the Institute enjoys strong institutional support. UT Austin provides the Institute with office space, meeting and research areas, laptop and desktop workstations, printing and duplication facilities, network infrastructure, and other administrative services and supplies. In addition to this in-kind support, the Institute's work is funded through a variety of strategic partnerships and initiatives at national, state, and local levels (UTeach Institute, 2018b). Over the last decade, the Institute has responsibly managed $35 million in support of UTeach program expansion, ongoing monitoring and support of established UTeach programs and their graduates, and related STEM education initiatives.

Project Management and Oversight. The Institute will maintain primary oversight and has identified all responsible staff and project stakeholders. The Institute will provide program development, grant administration, implementation support, technical assistance, and data collection services. Partner programs will enter into sub-award agreements with UT Austin (on behalf of the Institute) detailing partner program obligations.

The Institute maintains a staffing structure that allows us to oversee, support, and accommodate the scale-up of new program pathways at UTeach partner programs and the development and implementation of K–12 teacher professional development and ongoing implementation support. We employ qualified personnel, with the right balance of background and expertise (knowledge of teacher preparation, program evaluation, management experience, curriculum development experience, etc.). The organization chart (Appendix E) illustrates the Institute's current staffing structure, which includes a director, management s taff, site coordination staff, evaluators, content and communications staff, a financial analyst, a system analyst, a planning and event coordinator, and IT and administrative support staff. Appendix F contains résumés from key personnel.

Institute managers primary responsibilities include strategic planning, oversight of curriculum development, project evaluation design and development, instructional and operations support design and implementation, and data analysis and reporting.

Site coordination and evaluation staff are responsibilities for coordinating and providing direct operational and instructional technical assistance, scheduling and conducting site visits, recording data collected during site visits, analyzing data to determine technical assistance needs, and reporting to managers. Content and communications staff, including an instructional designed, are responsible for K-12 and STEM content and curriculum development and dissemination via secure web-based applications.

The UTeach CS initiative is overseen by the Manager for CS, in coordination with the Associate Director for K–12 Initiatives. Teacher support specialists conduct teacher professional development and provide on-demand, ongoing course implementation support.

C.3 Procedures to Ensure Feedback and Continuous Improvement

The Institute's approach to program development and implementation ensures regular feedback and continuous improvement. For both goals, program site coordinators and teacher support specialists are available on-demand to address questions and concerns as they come up at partner program sites and among classroom teachers. Formal mechanisms are in place to collect, document, and analyze feedback for the purposes of continuous program improvement. For Goal 1, all site visit activities are documented and reported back to programs and in aggregate each semester. Program co-directors, staff, and faculty are formally convened regularly on site visits and feedback is solicited using interview and focus group protocols. Program implementation data are collected each semester and analyzed against established benchmarks and annual progress reports are prepared. For Goal 2, the course development process includes hiring classroom teachers as consultants during the pilot year to regularly provide formal feedback on course content, materials, and instructional approaches. Pre- and post-professional development, and end of year course implementation surveys are administered to collect data on quality and efficacy of training and curriculum and support.

D. PROJECT EVALUATION

The Institute will partner with the American Institutes for Research (AIR) to provide a comprehensive evaluation that includes (1) a Cluster Randomized Control Trial (CRCT) study (that meets What Works Clearinghouse (WWC) standards (without reservations) to assess long-term project impacts on intended outcomes and (2) a formative, continuous improvement evaluation to provide iterative, performance feedback to support project leadership to design, test, and refine program practices and address interim, developmental outcomes.

D. 1 Cluster Randomized Controlled Trial (CRCT) that meets WWC standards

As part of the goal to prepare in-service CS teachers, AIR will conduct an impact study using a CRCT design to assess the impact of ongoing teacher support on the implementation of UTeach CS curriculum. Beginning in year 2, and in concert with the PDSA cycles and rapid-cycle testing (described below), the CRCT study will assess the impacts of ongoing supports on teacher and student outcomes by randomly assigning 160 high school CS teachers to one of two conditions: 1) those who receive ongoing supports following in-service PD and 2) those who do not receive the support.

D.2 Performance Feedback and Assessment of Progress in Achieving Intended Outcomes.

Because UTeach partners and UTeach CS are primarily in design and development stage of their programs, it is important to periodically assess progress in their development by routinely examining which aspects or version of the programs that are most effective before implementing and evaluating the final version at scale. As described above, the Institute has formal mechanisms to foster an environment for continuous improvement among key stakeholders of both project goals. The evaluation uses a two-part approach: (1) supporting the UTeach partner programs and the in-service teacher support providers during continuous improvement cycles using a Plan, Do, Study, Act (PDSA) (Imai, 1986) approach and (2) rapid-cycle tests to maximize the impacts of specific strategies and program components for alternative preparation pathways and ongoing in-service teacher supports.

PDSA Cycles. Institute evaluation staff will guide steering committee members and the UTeach CS teacher support specialists through continuous cycles of design, implementation, testing, and redesign, using PDSA cycles . Participants will engage in periodic discussions to review data collected, reflect on what is working, and develop adaptations for the next stage o implementation. Each cycle builds on what was learned in the previous one, and, as a result, participants move closer to the targets they hope to achieve.

Rapid Cycle Studies. PDSA cycles may be significantly strengthened with rigorous rapid-cycle studies bringing more low-cost, short-duration experimentation into the developmer and early evaluation process. AIR will conduct rapid-cycle studies using efficient experimental designs, such as A- B testing or factorial experiments. In contrast to AIR's proposed CRCT (described above), which is designed to measure impacts on long-term outcomes, the rapid-cycle studies are shorter (e.g., weeks or months instead of years); test specific aspects of the programs with the goal of informing further development and refinement; and focus on more proximal outcomes, such as increased teacher confidence and skills implementing project-based learning.

D.3 Objective Performance Measures of Intended Outcomes (Qualitative and Quantitative)

Tables 5 and 6 link each proposed data source to research questions for the CRCT and continuous improvement evaluation studies respectively.

Impact Evaluation Measures

Extant Administrative Data. AIR will use district and state administrative data to answer the impact research questions. AIR will collect individual-level student and teacher data from districts recruited for the study. Student data will include AP CS exam scores and demographics such as gender, race/ethnicity, and socioeconomic status. Teacher data will include certifications, licensing, evaluation scores, teaching experience, and demographics (e.g., gender, race/ethnicity). AIR will supplement all extant data sources with information reported in the Common Core of Data (CCD).

Student and Teacher Surveys. AIR will develop and administer surveys to treatment and control teachers and students in the spring of year 2 and 3 of the study. Teacher surveys will gather information on teacher background and experience, including educational credentials, gender, age, and race/ethnicity. Surveys also will include questions to capture teacher CS content knowledge and views toward teaching, and including job satisfaction and commitment.

Student surveys will collect information on student background, grade level, experience with CS courses, as well as nonacademic scales regarding student engagement and interest in learning CS. AIR will pilot test and finalize teacher and student survey items/scales.

Teacher/Classroom Observations and Interviews. AIR staff will conduct in-person classroom observations of all CS teachers in the fall and spring during the course of the study. Observation instruments will be finalized during the planning year to measure teacher PBL practice and fidelity of implementation to the UTeach CS curriculum, using standardized instruments, including the UTeach Observation Protocol (UTOP). UTOP assesses the quality of STEM instruction on 27 items, each rated on a 5-point scale.

Student Assessments. As indicated above, AIR will use administrative student data collected by districts and states, such as AP CS exam scores to address the impact research questions.

In addition, AIR will identify, assess, and consider utilizing newly developed assessments of computational thinking skills and practices (e.g., Bienkowski, Snow, Rutstein, & Grover, S., 2015). These assessments will be administered to students in their schools during their CS classroom periods in the fall and spring of each school year.

Continuous Improvement Evaluation Measures

Archival Partner University and District Data. The Institute will collect and house school district, university and program-level and teacher candidate-level including enrollment, UTeach course roster, certification and student demographic and academic information.

Steering Committee Member Interviews.The Institute will conduct 30-minute interviews of UTeach program administrators and faculty responsible for designing and implementing the alternative preparation pathways twice a year. These interviews will provide information related to challenges and successes with implementation of the new pathways. Interviews will be recorded, with permission, and transcribed to ensure accuracy.

Surveys. The Institute will administer periodic surveys to each cohort of teacher candidates enrolled in the alternative pathways and in-service teachers who have participated in UTeachCS PD. The Teacher Candidate Survey includes questions related to the teacher candidates' experiences in UTeach courses, Internship year support, perceptions of program features, the degree to which they feel prepared to teach, and their levels of confidence and concerns related to implementing project-based learning. TheIn-Service Teacher Survey includes questions about skills and knowledge gained from the PD, its usefulness and effectiveness, as well as experience implementing the UTeach CS curriculum.

D.4 Methods Provide Valid and Reliable Performance Data on Relevant Outcomes

AIR will use experimental and continuous improvement research designs to evaluate the new UTeach STEM alternative pathways and APCS Principles PD and ongoing support services .

AIR will use a multiyear, multisite, experimental research design to evaluate the UTeach ongoing support to in-service CS teachers. Eighty teachers will be randomly assigned to receive ongoing supports (treatment group) or not (control group) in each of the two years of the study (total 160). AIR will follow teachers and their students for one year to assess the impact of having a year of ongoing support in addition to in-service PD versus just having received in-service PD. A power analysis indicates that the study will be adequately powered to detect a minimum effect of 0.12 standard deviation for academic outcomes and 0.14 for nonacademic outcomes, assuming a balanced sample of 3,200 students (minimum one section per teacher or 20 students) across 160 teachers (80 treatment and 80 control teachers). [1] If implemented as planned, the study of the impact of UTeach ongoing teacher supports on high school student achievement and nonacademic outcomes will meet WWC evidence standards without reservations (Institute of Education Sciences, 2017) for all outcomes examined.

A-B testing and factorial experiments will be used in the rapid-cycle studies to compare components of the programs with each other, isolate individual effects, and estimate the effects of the components in combination. For example, these designs could be used to compare standard candidate recruitment materials of the UTeach program with an enhanced version for post-baccalaureates to determine whether similar recruitment outcomes can be achieved. These designs could also test one professional learning module of the CS Principles PD (PBL) with a different model of the PD (programing languages). Table 7 lists the continuous evaluation and impact study timeline and activities.

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[1] Our assumptions for the power analysis are based on using a two-level model (students nested within classrooms) with student- and classroom-level covariates. Assumptions include $\alpha = 0.05$ for a $\beta = 0.80$, 20 students per classroom, balanced assignment to groups, $r^2 = 50\%$ at level 1 (40% for social-emotional outcomes), and $r^2 = 60\%$ at level 2.

Table 5. UTeach CS Impact Research Study Questions, Data Sources, and Collection Agencies

Impact Research Questions for Goal 2: Preparation of in-service teachers		Data Sources (Collecting Agency)			
	School Characteristics (CCD)	Teacher, and Student, Administrative Data (Districts)	Teacher and Student Survey (AIR)	Teacher/ Class Observations and Interviews (AIR)	AP Tests and CT Assessments (Districts and AIR)
1. What is the impact of UTeach CSP ongoing supports on teacher classroom project-based learning instructional practices and fidelity to the CSP curricula?			X	X	
2. What is the impact of UTeach CSP ongoing supports on student non-academic outcomes, such as attendance, discipline, interest, and engagement in CS courses?			X	X	
3. What is the impact of UTeach CSP ongoing supports on student academic outcomes, such as AP CSP exam scores and assessments of computational thinking skills and practices?				X	X
4. To what extent does the impact of UTeach CSP ongoing supports on teacher and student outcomes vary by school, teacher and student characteristics, such as school location, teacher background, and student demographics?	X	X	X	X	X
5. To what extent does the impact of UTeach CSP ongoing supports on student outcomes vary by use of PBL instructional practices and teacher fidelity to the curriculum?			X	X	X

Table 6. UTeach Continuous Improvement Evaluation Questions and Data Sources

Continuous Improvement Research Questions	Data Sources (Collecting Agency)			
	Partner University and District Data	**Steering Committee Interviews**	**Teacher Candidate Survey**	**In-Service Teacher Survey**
Goal 1: Strategic Expansion of UTeach Preparation Pathways				
1. To what extent do the existing UTeach courses meet the needs of career changers, returning military, and recent STEM graduates? What adaptations are needed?	X	X	X	
2. What cultural and contextual factors influence the design and implementation of the new UTeach STEM alternative and post-baccalaureate pathways?	X	X	X	
3. Does one version or component of the new UTeach STEM alternative and post-baccalaureate pathways benefit teacher candidates and high school students more than another?	X	X	X	
4. To what extent are the UTeach STEM alternative and post-baccalaureate pathways sustainable?		X	X	
Goal 2: Preparation of In-Service CS Teachers				
1. To what extent does the CSP PD and ongoing support services meet the needs of in-service teachers in terms of implementing the CSP curriculum? What adaptations are needed?				X
2. What cultural and contextual factors influence the in-service teachers' implementation of the CSP curriculum?				X
3. Does one version or component of the CSP PD and ongoing teacher support benefit high school teachers and students more than another?	X			X
4. To what extent is the CSP curriculum sustainable in schools?				X

Table7. Continuous Improvement Evaluation and Impact Research Study Timeline and Activities

	Formal Project Period									Extension Period					
	2018	2019			2020			2021		2021	2022		2023		
F=Fall; S=Spring; Su=Summer	F	S	Su	F	S	Su	F	S	Su	F	S	Su	F	S	Su
1. Continuous Improvement Evaluation and Ongoing Monitoring *AIR Staff; Institute Staff: Associate Director, Site Coordinators, Data and Evaluation Coordinator*															
1.1 Develop and refine performance measures	X	X			X			X			X			X	
1.2 Collect evaluation baseline data		X													
1.3 Develop and refine evaluation protocols, surveys, PDSA worksheets	X	X					X						X		
1.4. Assess program alignment to the UTeach Model					X				X			X			X
1.4 Retrieve and analyze partner program/district archival data from the UTeach Institute	X			X			X			X			X		
1.5 Conduct interviews and site visits					X			X			X			X	
1.6 Administer and analyze CSP teacher survey			X			X			X			X			X
1.7 Administer and analyze teacher candidate survey				X	X		X	X		X	X		X	X	
1.8 Conduct PDSA reflection and planning meetings			X			X			X			X			X
1.9 Internship year data collection and observations					X			X			X			X	
1.10 Program graduates tracking and employment				X	X		X	X		X	X		X	X	
2. Impact Study *AIR Staff*															
2.1 Instrument development	X														
2.2 Research design, assignment, & analysis plans	X		X			X			X			X			
2.2 Data collection (teacher and student survey, student assessments, and classroom observations				X	X		X	X		X	X		X	X	
2.3 Data analysis and reporting						X			X			X			X
3. Communications															
3.1 Develop, submit annual, evaluation reports			X			X			X			X			X
3.2 Conferences and publications								X	X					X	X

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