## Expanding Access and Opportunity Through Culturally Responsive Computer Science (CURE CompSci)

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INTRODUCTION AND PRIORITIES. Uncommon Schools' early-phase EIR proposal — Expanding Access and Opportunity Through **Cu**lturally **Re**sponsive **Comp**uter **Sci**ence (**CURE CompSci**) — broadens opportunities for Black and Latinx students to succeed as computer scientists by allowing them to build a foundation of computational thinking (CT) skills prior to engaging in CS coursework. By using a culturally responsive computing framework to support the delivery of CT units in Grade 9 and 10 Math and Science courses, CURE CompSci ensures all students — not just those who enter high school intent on pursuing CS studies — are encouraged to see themselves as integral members of a thriving and inclusive CS community.

CURE CompSci represents a novel, sustainable, and replicable approach that will impact over 8,500 low-income Black and Latinx students in nine schools across five regions in three states (New York City and Rochester, NY; Newark and Camden, NJ; and Boston, MA) and will provide critical research. Uncommon Schools ("Uncommon" or "USI") is well-positioned to achieve breakthrough outcomes. It has a decades-long track record of narrowing and even reversing historic achievement gaps for underserved students and has implemented an i3 grant that resulted in significant positive impacts on ELA and Math performance. Mathematica, its evaluation partner, is a national leader in social policy research with over 50 years of experience evaluating federally funded programs including eight recent evaluations of i3/EIR grants.

This project addresses **Absolute Priorities 1** (Demonstrates a Rationale) and **3** (Field-Initiated Innovations—STEM) and **three competitive preference priorities**.

COMPETITIVE PREFERENCE PRIORITY 1 — COMPUTER SCIENCE. Black and Latinx students are materially less likely than their peers to attend schools that offer AP CS courses, to participate in CS programming, to succeed on AP CS exams, and to obtain high-wage computing jobs. CURE CompSci systematically addresses the structural barriers that prevent underrepresented students

from achieving their full computing potential through an innovative, research-based approach to integrating culturally responsive computing instruction in high school.

COMPETITIVE PREFERENCE PRIORITY 2 — ADDRESSING THE IMPACT OF COVID-19. The Massachusetts, New Jersey, and New York American Rescue Plan ESSER State Plans confirm that low-income students of color were disproportionately affected by the dislocations occasioned by COVID-19 (MA DESE, 2021; NJDOE, 2021; NYSED, 2021). CURE CompSci addresses the impact of COVID-19 in these three states *not only* by accelerating learning in high school Math and Science to address the impact of lost instructional time on low-income Black and Latinx students *but also* by thinking beyond recovery and equipping these students with the skills needed to thrive in the competitive global economy. This approach, which strengthens the connection between historically underserved students and their schools by creating learning environments in which cultural backgrounds serve as the building blocks for constructing computing identities, honors input from USI families about how to build back better and not simply revert to an inequitable pre-pandemic *status quo*.

COMPETITIVE PREFERENCE PRIORITY 3 — PROMOTING EQUITY AND ADEQUACY. A laser focus on equity permeates each of CURE CompSci's core elements. Curricular content and environmental design center the lived experiences of underserved students, decreasing the conceptual distance between students' cultures and the world of STEM-CS. Professional Development (PD) surfaces and addresses implicit biases that shape the manner in which educators understand the potential of Black and Latinx students to succeed in CS. Because the rigorous, culturally responsive CT units are embedded in general education Math and Science, *all* students — not just those with an interest in (and aptitude for) STEM-CS learning — have the potential to benefit from foundational learning experiences that drive participation and success in AP CS courses.

## A. Significance

**A.1. Promising Strategies.** CURE CompSci will enhance the field's understanding of how to increase access, participation, and success in CS for Black and Latinx students — sustainably and at scale — by using a culturally responsive computing framework to integrate key interventions. Efforts to remedy the inequities in CS education have largely consisted of attitudinal, environmental, and curricular interventions. Each has yielded benefits. Attitudinal interventions are designed to combat the stereotypes and biases that cause Black and Latinx students to internalize negative perceptions about the extent to which they "belong" in the CS field and have resulted in increases in student self-efficacy (Burnette et al., 2020; DiSalvo et al., 2013; Lakenen & Kärkkäinen, 2019; Lang et al., 2016; Phillips & Brooks, 2017; Scott & White, 2013; Taub et al., 2009). Environmental interventions target the conditions in which Black and Latinx students learn CS and have demonstrated effectiveness at creating inclusive and equitable learning spaces (Cheryan et al., 2015; Eglash et al., 2013; Flapan et al., 2020; Vakil, 2018). Curricular interventions acknowledge the inadequacy of traditional CS coursework and infuse CS curricula with content that is explicitly designed to be more relevant and engaging for Black and Latinx students (Flapan et al., 2020; Koshy et al., 2021; Margolis et al. 2008; Nakajima & Goode, 2020; Scott et al., 2014; Scott et al., 2015; Washington, 2020).

Nevertheless, educational leaders have routinely eschewed innovative and integrated approaches in favor of piecemeal efforts incapable of effecting systemic change at scale. Frequently cited barriers to comprehensive approaches include a dearth of qualified teachers, inadequate funding, finite scheduling availability, and a perceived lack of demand and buy-in from key stakeholders, (Google & Gallup, 2016b; Vegas & Fowler, 2020; Wang et al., 2016). Critically, studies that have been conducted on interventions designed to broaden access and

participation within CS "do not provide the kind of rigorous impact assessment one would need to make a definitive conclusion of their effectiveness" (Vegas & Fowler, 2020). Multiple evaluations have discerned short-term positive effects on self-reported attitudinal indicia but have refrained from drawing causal conclusions about the impact of interventions on long-term enrollment, retention, and performance data (Burnette et al., 2020; Guzdial et al., 2013).

USI's proposed project will bring all three strands — curricular, attitudinal, and environmental — together within a holistic intervention while using a **Culturally Responsive Computing** (CRC) framework to ensure alignment. CRC rests on the foundational premise that the sociocultural identities of Black and Latinx students are the essential building blocks for the creation of computing identities (Koshy et al., 2021; Morales-Chicas et al., 2019; Scott & White, 2013; Vakil, 2018). By centering the lived experiences of students and framing computing as a means to address pressing social justice issues within their own communities, CRC reconceptualizes the relationship between Black and Latinx students and CS (Goode et al., 2018; Scott et al., 2014; Scott et al., 2015; Vakil, 2018). By emphasizing the importance of community connections, CRC envisions CS as a field not merely grudgingly tolerant of Black and Latinx participation but instead actively solicitous of their presence (Charleston et al., 2014; Nakajima & Goode, 2020; Scott et al., 2014; Scott et al., 2015; Washington et al., 2019).

USI is well-qualified to implement an initiative that uses CRC to drive outcomes for underserved students. Nearly 95% of USI students are Black or Latinx (see Appendix J). In 2018–19, 53% of Black students and 57% of Latinx students participated in AP courses with 66% of participating Black students and 68% of participating Latinx students receiving scores of 3 or higher on their exams. These passing rates far outpace the national averages for Black (41%) and Latinx (52%) students and close the achievement gap with white students (67%). Among

charter school systems designated as "super networks," USI was found by Stanford's Center for Research on Education Outcomes to have the largest and most significant positive effects on both Reading and Math outcomes, providing students with the equivalent of *137 days of additional learning annually* in Math (Woodworth & Raymond, 2013; Woodworth et al., 2017).

USI has achieved these breakthrough results by drawing on the culturally responsive teaching principles expounded by Zaretta Hammond (2014) (see Appendix J), and by utilizing its heralded *Teach Like a Champion* framework to develop replicable PD structures and recursive coaching practices that ensure effective delivery of high-quality curricula. *By using CRC to marry the hallmarks of successful attitudinal, curricular, and environmental interventions with USI's proven model, CURE CompSci will demonstrate how an integrated solution to a persistent educational problem can work at scale, demonstrate sustainability, and be subjected to a rigorous evaluation that meets What Works Clearinghouse (WWC) standards.*

A.2. DISSEMINATION. A commitment to codifying and sharing best practices is woven deeply into USI's DNA. Books such as *Teach Like a Champion*, *Practice Perfect*, and *Driven by Data* exemplify this work. The first alone has sold over 2 million copies, created a new taxonomy for talking about teaching, and spawned widely licensed PD materials. USI's High School Curriculum Hub provides free access to a library of AP-aligned resources. Moreover, USI has improved struggling schools and LEAs in multiple states through its instructional training for district leaders and teachers, impacting thousands of students annually (Flanagan, 2019).

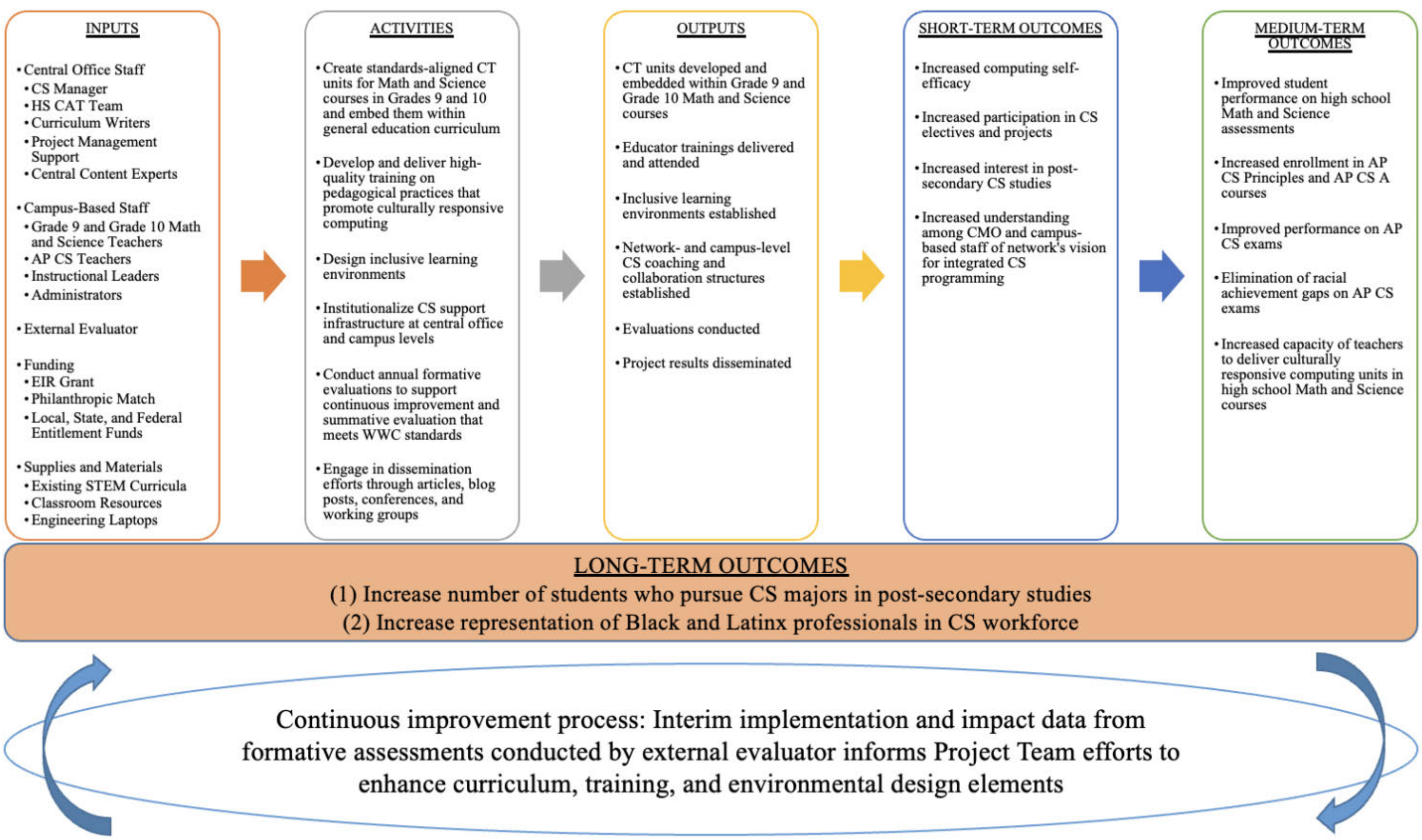
An investment in CURE CompSci will yield significant returns for the field. All project materials will be shared and featured on the Curriculum Hub, which generates significant traffic among frontline educators. USI will present findings at local, regional, and national conferences ranging from those that focus on K–12 CS education (including the CSTA Annual Conference

and the SIGCSE Technical Symposium) to those that host broader cross-sections of educators. In addition to sharing data and practices annually with the Charter School Growth Fund working group (10 high-performing charter networks that educate over 225,000 underserved students), USI will contribute to the i3/EIR CS Community and will share effective CS practices with our district partners. USI will also secure publication of at least three pieces in practitioner- or public-facing media during the grant. Finally, Mathematica will publish a summative evaluation that highlights replicable practices and is shared through scholarly journals and the WWC.

## B. Quality of the Project Design

**B.1. Conceptual Framework.** CURE CompSci represents a holistic approach to dismantling the systemic barriers that limit access, participation, and success in computing education.

Figure 1: CURE CompSci Logic Model



CURE CompSci is anchored in a conceptual framework that provides a clear nexus between proposed activities and intended outcomes. The project combines **four innovative design elements** — (1) embedding CS within the general education curriculum; (2) centering student identity; (3) equipping educators to empower students; and (4) designing for sustainability — to enhance students' CS self-efficacy, increase participation in CS electives and AP courses, improve performance in Math and Science courses and on AP CS exams, and increase interest in CS-focused post-secondary pathways and careers.

<u>(1) Embedding computing within the general education curriculum</u>. Among the principal reasons that interventions designed to broaden access to CS fall short of their objectives is a failure to account for barriers that preclude participation in elective programming. CT unlocks an individual's "capacity for innovation," (Kukul & Karatas, 2019, p. 152), and "provides students with tools and skills to approach and solve a wide range of problems in different areas of knowledge" (Flórez et al., 2017, p. 834). While studies have shown that embedding CT in core classes may lead to positive impacts not only in CS courses but in core subjects as well (Rodríguez-Martinez et al., 2020), design challenges often hamstring efforts to infuse STEM courses with CT principles (Basu et al., 2016). Thus, while the idea of exposing students to CT concepts within their K–12 classes has gained traction, the "majority" of such efforts have remained centered on standalone computing courses (Yadav et al., 2016, p. 566). Vallett et al. (2018) have called into question the effectiveness of interventions to redress underrepresentation in STEM-CS that are confined to after-school and elective settings as they are poorly designed to reach students who have already self-selected out of the field.

**To account for the possibility that an elective-focused intervention would exclude the students who would most benefit from exposure to culturally responsive computing**

**content, CURE CompSci embeds computational thinking units in five courses across the general education high school curriculum. Sequencing these units at the start of high school will allow students to build their CS interest and self-efficacy before deciding whether to pursue CS-focused projects, sign up for CS electives, or enroll in AP CS courses.**

In **Algebra I**, students will (a) study geometric sequences where they will analyze and recognize patterns and will generate formulas to predict future values within that pattern (CCSS Math Building Functions HSF-BF.A.2), and (b) explore how linear data is represented through graphical representations (8.SP.A.1). In **Algebra II**, students will explore the relationship between exponential and logarithmic functions by analyzing different search-and-sort algorithms, classify these algorithms as linear or exponential/logarithmic, and compare their efficiencies (HSF.BF.B.5). In **Geometry**, students will construct algorithms that model the algebraic representation of functions being transformed on the coordinate plane (HSG.CO.A.5).

In **Pre-AP Biology**, students will leverage various types of sensors to collect large amounts of data from an experimental setup and will use computer-based programs and tools to analyze these data and to identify trends and mathematical relationships between the variables (NGSS Science and Engineering Practices 3, 4, and 5). In **Pre-AP Chemistry**, CT will be built into the study of the periodic table as students recognize and analyze patterns in subatomic particles and apply algorithmic thinking to identify trends in the placement of elements or interactions between atoms, ions and molecules (HS-PS1-2, HS-PS2-4). Students may also create computational models that represent heat transfers between systems (HS-PS3-1), and use computer-based tools to analyze data collected from experimental setups (SEP-3, 4, and 5).

(2) Centering student identity. CURE CompSci is grounded in an asset-based approach. When situated within the CRC framework, CT equips students with problem-solving strategies

that can be used to navigate issues that implicate social justice (Eglash et al., 2013; Scott et al., 2014; Vakil, 2018). Morales-Chicas et al. (2019) stress centering lived experiences and community connections for "sociopolitical consciousness raising" (p. 132), while Koshy et al. (2021) argue that achieving equity in CS will require schools to develop students' "critical consciousness" by creating opportunities to tackle community issues using computing (p. 17).

From a *curricular* standpoint, CURE CompSci will align the five CT units with three high-leverage CSTA K–12 CS Standards that have been selected not only for their congruence with Math and Science standards but also for their compatibility with the tenets of CRC:

- *3A-DA-11: Create interactive data visualizations using software tools to help others better understand real-world phenomena (Geometry, Pre-AP Bio, Chemistry, & Algebra II)*

- *3A-DA-12: Create computational models that represent the relationship among different elements of data collected from a phenomenon or process (Algebra I & Pre-AP Bio)*

- *3A-AP-13: Create prototypes that use algorithms to solve computational problems by leveraging prior student knowledge and personal interests (Algebra II)*

Consistent with USI's recent adoption of more authentic STEM assessments that allow students to demonstrate knowledge through performance tasks rather than through traditional written exams, these units will culminate with students producing computational artifacts that connect course content to the real world. For example, students in Algebra II may use logarithmic and exponential models to represent and better understand loan amortization. Throughout the project period, the Curriculum and Assessment Team will also refine existing AP CS Principles and CS A curricula to ensure adherence to the tenets of CRC.

From an *environmental* standpoint, CURE CompSci recognizes that learning spaces that create a sense of "ambient belonging" can counteract insidious stereotypes (Cheryan et al., 2015, p. 5). CURE CompSci will (1) develop signage that showcases a diverse array of researchers, scientists, and mathematicians; (2) cultivate a collaborative spirit and an understanding of

collective capacity as key to solving complex computing problems; (3) feature computational artifacts in hallways and classrooms; and (4) equip labs with computing technology (e.g., gas, electronic temperature, and pH sensors) to collect and analyze data on a large scale.

Providing students with ethnically relevant CS role models is another proven way of signaling belonging (Charleston et al., 2014; Washington, 2020; Washington et al., 2019). Across the Uncommon network, more than 60% of staff and nearly 50% of principals identify as people of color, percentages that dramatically exceed national averages (NCES, 2018a; NCES, 2018b). Accordingly, the physical and demographic features of the settings in which students learn STEM-CS will bear the hallmarks of successful environmental interventions.

(3) Equipping educators to empower students. A condition precedent to the delivery of an effective culturally responsive computing program is the presence of educators who believe deeply in the potential of all students to succeed in CS. Results from a recent nationwide survey indicate that teachers' perceptions of the barriers that impede access to CS programming for Black and Latinx students frequently reveal "mindsets, perceptions, and practices that uphold systems of oppression" (Koshy et al., 2021, p. 16). Goode et al. (2018) studied the extent to which PD prepares educators to deliver equitable CS instruction and found that "purposeful integration of dialogue around race and CS education . . . [can] lead to teachers' increased capacity to teach racially diverse students without defaulting to a colorblind pedagogy."

CURE CompSci builds the capacity of educators to deliver CT content in a culturally responsive fashion by investing in periodic training and ongoing coaching of Math, Science, and CS instructors. Educators will attend annual PD workshops that focus on both the curricular and pedagogical aspects of equitably delivering computing instruction. With capacity-building support from Central Content Experts, Instructional Leaders (ILs) will provide teachers with

weekly real-time feedback using Uncommon's renowned *Teach Like a Champion* framework. And members of the CURE CompSci Management Team will conduct triannual school reviews against a rubric that incorporates indicia of CRC.

(4) Designing for sustainability. The benefits that accrue to students from 'successful' interventions are often fleeting; when dedicated funding streams are discontinued, the lack of an institutional support structure can prove fatal to a program's continued viability (Sarrafzadegan et al., 2014). Implementation science literature speaks to additional challenges that complicate sustainability planning when a program is adopted in a range of settings (Shelton et al., 2018). Thus, for an innovative program that will be implemented across three states, it is imperative that the factors undergirding the sustainability of evidence-based practices — which include organizational and community capacity building, adaptation based on formative evaluations, and instantiation within policies and systems — be considered *ex ante* and baked into the program design from conception (Pinkelman et al., 2015; Shelton et al., 2018; Whelan et al., 2014).

To ensure the durability of CURE CompSci beyond the EIR grant, Uncommon will institutionalize the key components of the project. CURE CompSci will build on Uncommon's PD model — which includes replicable structures for co-planning, data review, and coaching — to build the institutional and individual capacity necessary to sustain a culturally responsive computing program. By hiring a CS Manager to work in collaboration with its Math and Science Directors, USI will ensure alignment between the Math and Science classes in which the CT units are embedded, CS electives and projects, and AP courses.

B.2. GOALS, OBJECTIVES, AND OUTCOMES. USI has established a set of ambitious yet attainable goals, objectives, and outcomes that CURE CompSci will achieve over the EIR project period.

Table 1. Project Goals, Objectives, Outcomes, and Performance Measures

| **Measure** | **Data Source** | **Outcomes** |
|---|---|---|
| *Objective 1: Increase access to, participation in, and success in CS opportunities for underserved students.* | | |
| 1.1. Computing self-efficacy | Survey data | Students in Treatment Schools express agreement or strong agreement with relevant survey measures by an average of 10 percentage points more than students at Control Schools |
| 1.2 Participation in CS electives and projects | Internal enrollment data | Percentage of students in Treatment Schools who enroll in non-AP CS elective courses or select CS projects remains at least 5 percentage points higher than at Control Schools throughout the project period |
| 1.3. Access to AP CS coursework | Internal enrollment data | (a) Network-wide enrollment in AP CS courses increases by 3 percentage points annually; (b) Enrollment in AP CS courses at Treatment Schools exceeds enrollment in Control Schools by 5 percentage points annually |
| 1.4. Participation in AP CS exams | College Board data | (a) The number of AP CS exams taken by students in Grades 11-12 increases by at least 2 percentage points annually during the project period; (b) Participation in AP CS exams at Treatment Schools exceeds enrollment in Control schools by at least 5 percentage points annually |
| 1.5. Performance on Math and Science Exams | Interim Assessment data | Students in Treatment Schools outperform students in Control Schools on Interim Assessments in Grade 9 and 10 Math and Science courses by an average of least 5 percentage points annually during the project period |
| 1.6. Outcomes on AP CS exams | College Board data | (a) Pass rates on AP CS exams at Treatment Schools exceeds the pass rates in Control schools by 8 percentage points annually; (b) In Years 3–5, mean network-wide scores on AP CS exams exceed the Y0 baseline scores by at least 0.3 points; (c) In Years 3–5, Black and Latinx students outperform the national mean scores on AP CS exams |
| 1.7. Interest in post-secondary CS studies and careers | Survey data | Students in Treatment Schools express agreement or strong agreement with relevant survey measures by an average of 10 percentage points more than students at Control Schools |
| *Objective 2: Demonstrate the scalability and sustainability of CURE CompSci as an integrated, culturally responsive computing initiative.* | | |
| 2.1. CRC curricula | Survey data | Over 85% of teachers and students agree with survey prompts related to the relevance of the content in their Math, Science, and CS courses. |
| 2.2. CRC instruction | PD attendance and survey data | (a) At least 25 teachers attend CRC trainings annually; (b) At least 85% of participants agree with PD feedback survey prompts related to the quality, relevance, and usefulness of the trainings |
| 2.3. Inclusive CS learning environments | School design and survey data | (a) Each campus outfits between 1 and 3 classrooms with essential CS resources during the project period; (b) At least 85% of teachers and students agree with survey prompts pertaining to the manner in which their learning environments create a sense of belonging in CS |
| 2.4. Whole-school and whole-network approaches to CS | Internal staffing data; survey data | (a) Hire CS Manager and 2 curriculum writers; (b) 100% of CURE CompSci teachers receive weekly coaching; (c) At least 85% of teachers agree that they have received the resources, training, and coaching necessary to deliver and sustain CURE CompSci programming |
| 2.5. Financial sustainability | Budgetary data | (a) Raise at least $400,000 in matching funds; (b) Maintain an annual per-student cost of under $470 to facilitate sustained implementation beyond the project period |
| *Objective 3: Contribute to the growing evidence base of effective strategies for increasing access, participation, and success in CS.* | | |
| 3.1. Continuous improvement | Formative evaluations | In response to ongoing performance feedback, make at least one major program design improvement annually throughout project period |
| 3.2. Implementation study | Summative evaluation | Independent evaluator publishes implementation study that describes key programmatic elements and facilitates replication in other settings |
| 3.3. Impact analysis | Summative evaluation | Independent evaluator conducts study on program outcomes that satisfies WWC 'moderate evidence' standards |

| Measure | Data Source | Outcomes |
|---|---|---|
| 3.4. Dissemination | Publications, conferences | Complete at least two public knowledge dissemination activities annually |

B.3. ADDRESSING THE NEEDS OF THE TARGET POPULATION. CURE CompSci is explicitly designed to address four inequities that afflict Black and Latinx students within CS education.

*Inequity #1: Access to CS Coursework.* Structural barriers limit Black and Latinx students' access to CS education (Flapan et al., 2020; Vegas & Fowler, 2020; Washington, 2020). In New Jersey, Black and Latinx students are 1.6 times less likely than their white and Asian peers to attend a school that offers an AP CS course (Code.org et al., 2020). Opportunities for students to build the foundational, domain-specific knowledge to succeed in an AP setting are also foreclosed: nationally, Black students are disproportionately less likely than their peers to attend schools that offer dedicated CS courses, and Latinx students are disproportionately less likely than their peers to say that they have learned CS (Google & Gallup, 2016a; Wang et al., 2016).

*Inequity #2: Participation in CS Programming.* Even when Black and Latinx students attend schools that offer discrete CS courses, cultural stereotypes, hostile environmental signals, unengaging curricula, and unsupportive adults depress their participation (Margolis et al., 2008; Wang et al., 2016). Nationally, Black and Latinx students account for 42% of students but only 23% of students taking AP CS exams (Code.org et al., 2020). In Mass., Black and Latinx students are more than 1.5 times less likely than their white and Asian counterparts to take an AP CS exam *even when* they attend a school that offers the AP course (Code.org et al., 2020).

*Inequity #3: AP Exam Success.* The same factors that contribute to low CS participation rates also result in Black and Latinx students achieving comparatively low pass rates on AP exams (Flapan et al., 2020; Google & Gallup, 2017; Margolis et al., 2008). According to data from the College Board (2020), 69.7% of all students taking the AP CS A exam in 2020 passed with a score of 3 or above. By contrast, 40.9% of Black students and 50.1% of Latinx students achieved

those scores. On the 2020 AP CS Principles exam, the 52.2% pass rate for Black students and 61.4% pass rate for Latinx students lagged the overall pass rate of 71.4%.

*Inequity #4: Workforce Opportunities*. Bureau of Labor Statistics forecasts indicate that STEM-CS jobs will represent the third-fastest growing sector of the economy over the next decade (DOL, 2020). Black and Latinx workers represent less than 20% of the workers in computing occupations (American Society for Engineering Education, 2019; DOL, 2021). With CS majors receiving nearly $600,000 more than other college graduates in lifetime earnings, these inequities perpetuate racial wealth gaps (Bhutta et al., 2020; McIntosh et al., 2020).

## C. Adequacy of Resources and Quality of the Management Plan

**C.1. Adequacy of Management Plan to Achieve Project Objectives**. The CURE CompSci management plan includes clearly defined responsibilities, timelines, and milestones. Uncommon's HS Chief of Staff will serve as the Project Director (PD). Working in collaboration USI's High School Curriculum and Assessment Team (CAT) and regional administrators, the PD will oversee the creation and refinement of the project's core components. With grant funds, USI will add a CS Manager to bring content expertise to the CAT team, which will spearhead this coordinated, robust initiative. Within the project's first six months, the CAT Team and curriculum writers will design the five CT units and the associated PD for the five treatment schools for implementation in 2022–23. The project team will execute refinements based on formative learning throughout the project, particularly between Years 1 and 2 in anticipation of implementation for a second treatment cohort in 2023–24. USI's CEO and HS Chief Schools Officer, who administered an i3 Grant that yielded statistically significant positive impacts on Math and ELA student achievement (Burnett et al., 2021), will lend project management expertise, provide dissemination support, and ensure network-wide alignment and investment.

Table 2. CURE CompSci Management Plan[1]

| | 2022 | | | | 2023 | | | | 2024 | | | | 2025 | | | | 2026 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F |
| **PROJECT MANAGEMENT** | | | | | | | | | | | | | | | | | | | | |
| Confer with ED; make necessary adjustments to project plan | ■ | | | | | | | | | | | | | | | | | | | |
| Confirm staffing, roles, and responsibilities; hire CS Manager and curriculum writers | ■ | | | | | | | | | | | | | | | | | | | |
| Build detailed operational plan for each year of the project and create project implementation tracking system | ■ | | | | | | | | | | | | | | | | | | | |
| Hold monthly Project Team meetings | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Evaluate project progress and set new goals | | ■ | | | | ■ | | | | ■ | | | | ■ | | | | ■ | | |
| Submit annual reports to ED | | | | ■ | | | | ■ | | | | ■ | | | | ■ | | | | ■ |
| **PROJECT IMPLEMENTATION** | | | | | | | | | | | | | | | | | | | | |
| *Initial Design & Implementation Cycle (Treatment Cohort 1)* | | | | | | | | | | | | | | | | | | | | |
| Draft CT units for G9 & G10 Math and Science courses | ■ | ■ | | | | | | | | | | | | | | | | | | |
| Design PD for Math, Science, and CS educators | ■ | ■ | | | | | | | | | | | | | | | | | | |
| Purchase supplies and materials for STEM-CS classrooms | | ■ | | | | | | | | | | | | | | | | | | |
| First draft and refinement of AP CS curricula | | ■ | ■ | | | | | | | | | | | | | | | | | |
| Complete CT units | | | ■ | | | | | | | | | | | | | | | | | |
| Set up STEM-CS classrooms | | | ■ | | | | | | | | | | | | | | | | | |
| Host two-day summer PD in culturally responsive computing for Math, Science, and CS educators | | | ■ | | | | | | | | | | | | | | | | | |
| Implement CURE CompSci in Treatment Schools | | | | ■ | ■ | ■ | | | | | | | | | | | | | | |
| Provide coaching and collaborative planning time (weekly) | | | | ■ | ■ | ■ | | | | | | | | | | | | | | |
| Conduct central office walkthroughs | | | | ■ | ■ | ■ | | | | | | | | | | | | | | |
| *Refinement Cycles (2023–24 for Treatment Cohort 2; 2024–25 and 25–26 for all Treatment and Control Cohorts)* | | | | | | | | | | | | | | | | | | | | |
| Evaluator reviews data with Project Team and provides feedback for continuous improvement efforts | | | | | | ■ | | | | ■ | | | | ■ | | | | | | |
| Complete first revision of CT units and PD based on formative learning | | | | | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | | | | | |
| Second draft and refinement of AP curricula based on formative learning from Year 1 | | | | | | ■ | ■ | | | | | | | | | | | | | |

[1] W = Winter; Sp = Spring; Su = Summer; F = Fall

| | 2022 | | | | 2023 | | | | 2024 | | | | 2025 | | | | 2026 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F |
| Host two-day summer PD in culturally responsive computing for Math, Science, and CS educators | | | | | | | ■ | | | | ■ | | | | ■ | | | | | |
| Implement CURE CompSci in Treatment Schools (23-24) & Treatment + Control Schools (24-25, 25-26) | | | | | | | | ■ | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | | |
| Provide coaching and collaborative planning time (weekly) | | | | | | | | ■ | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | | |
| Conduct central office walkthroughs | | | | | | | | ■ | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | | |
| **EVALUATION** | | | | | | | | | | | | | | | | | | | | |
| Finalize evaluation design; obtain IRB approval/exemption | | ■ | | | | | | | | | | | | | | | | | | |
| Administer end-of-course assessments and AP exams | | ■ | | | | ■ | | | | ■ | | | | ■ | | | | ■ | | |
| Develop survey items | | | | ■ | | | | | | | | | | | | | | | | |
| Develop focus group protocols | | | | ■ | | | | | | | | | | | | | | | | |
| Conduct focus groups with teachers and students | | | | | ■ | | | | ■ | | | | | | | | | | | |
| Analyze teacher and student focus group data | | | | | | ■ | | | | ■ | | | | | | | | | | |
| Administer teacher and student surveys | | | | | | ■ | | | | ■ | | | | ■ | | | | ■ | | |
| Collect, clean, and analyze exam, enrollment, and survey data | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Produce memo with performance feedback | | | | | | ■ | | | | ■ | | | | | | | | | | |
| Produce tables with performance feedback | | | | | | | | | | | | | | ■ | | | | | | |
| Publish final evaluation report | | | | | | | | | | | | | | | | | | | ■ | |
| **DISSEMINATION** | | | | | | | | | | | | | | | | | | | | |
| Share CT units and revised AP materials on Curriculum Hub | | | | | ■ | | | | ■ | | | | ■ | | | | ■ | | | |
| Publish blog posts on Uncommon Sense blog | | | | | | | | ■ | | | | ■ | | | | ■ | | | | |
| Share knowledge and best practices with CSGF working group and i3/EIR community | | | | | | | | ■ | | | | ■ | | | | ■ | | | | |
| Convey new knowledge through at least one print publication or one conference presentation annually | | | | ■ | | | | ■ | | | | ■ | | | | ■ | | | | ■ |
| Deliver at least one training annually on effective CS practices to traditional public school district partners | | | ■ | | | | ■ | | | | ■ | | | | ■ | | | | ■ | |
| Publish summative implementation & impact evaluation | | | | | | | | | | | | | | | | | | | | ■ |

C.2. QUALIFICATIONS OF KEY PROJECT PERSONNEL. CURE CompSci will be managed by highly qualified personnel who possess deep experience with projects of similar scope and scale.

Table 3. CURE CompSci Management Team Experience & Responsibilities

| Name/Title | CURE CompSci Responsibilities | Experience Highlights |
|---|---|---|
| [redacted], Chief Executive Officer | • Provide oversight of project design, implementation, and continuous improvement<br>• Secure and allocate necessary resources to promote project success | • Uncommon CEO since 2012: opened 25 new schools, managed fully enrolled schools on the public dollar, and oversaw CREDO evaluations<br>• Former Managing Director of Uncommon NYC and Founder of Boston Collegiate Charter Schools, one of the highest performing public schools in MA<br>• MPP in Education Policy, Harvard Kennedy School; BA, Brown University |
| [redacted], Chief Schools Officer, 9-12 | • Accountable for EIR 9-12 academic products, PD, and student outcomes<br>• Oversee dissemination of project outcomes and products | • CSO since 2015: oversees all HS instruction<br>• 12 years as Managing Director of North Star Academy<br>• Author of *Leverage Leadership* (2012); *Great Habits, Great Readers* (2013); and *Get Better Faster* (2016)<br>• MEd, New Leaders from CUNY-Baruch; BA, Duke U. |
| [redacted], Chief of Staff to the Chief Schools Officer, 9-12 | • Serve as **CURE CompSci Project Director**<br>• Oversee implementation of project in schools; build operational plan and implementation tracking system<br>• Serve as primary liaison with regional leaders; support project rollout on campuses<br>• Lead monthly Project Team meetings; oversee teacher coaching; coordinate central office walkthroughs | • Chief of Staff for High School since 2019 with 7 years of experience at Uncommon<br>• Founding Director of Operations at Uncommon Prep. Charter HS<br>• Classroom Teacher, Teach for America (2012-14)<br>• BA, University of Michigan |
| [redacted], Chief Financial Officer | • Ensure all EIR funds are used in allowable / appropriate ways and that reporting requirements are met<br>• Accountable for all financial aspects of EIR project | • Uncommon CFO since 2019; oversees financial planning, budgeting, and accounting including federal grants management<br>• 20+ years of experience in nonprofit finance<br>• MS, Financial Statement Analysis, Baruch College-CUNY; BA, Johns Hopkins University |
| [redacted], Senior Director of HS Curriculum & Assessment | • Oversee development of curricula, assessments, and training<br>• Coordinate efforts of Math, Science, and CS CAT team staff<br>• Coordinate and support PD for CURE CompSci teachers | • SD of HS Curriculum & Assessment Team since 2018<br>• Founding Principal, Uncommon Prep. Charter HS<br>• Completed National Principals Academy Fellowship and Leverage Leadership Institute at Relay Graduate School of Education<br>• EdM, Harvard Graduate School of Education; BA in Chemistry and English, Mount Holyoke College |
| [redacted], Director of 9-12 Science | • Oversee creation and refinement of computational thinking units for Grade 9 and 10 Science courses<br>• Support design, refinement, and delivery of PD | • Director of 9-12 Science since 2017<br>• Former science teacher and instructional leader at North Star Academy-Washington Park High School<br>• EdM in Education of Teachers in Science, Teachers College Columbia U.; BS in Biochemistry, UCLA |
| [redacted], Director of 9-12 Math | • Oversee creation and refinement of computational thinking units for Grade 9 and 10 Math courses<br>• Support design, refinement, and delivery of PD | • Director of 9-12 Math since 2019<br>• Former math teacher, instructional leader, and dept. chair at Uncommon Preparatory Charter High<br>• MAT in Secondary Math Ed., University of Louisville; BA in Mathematics, University of Rochester |

| | | |
|---|---|---|
| [redacted], Ph.D., Researcher (Mathematica) | ● Principal Investigator for the EIR evaluation<br>● Accountable for research and publication of the EIR study | ● Researcher and lead author on USI's i3 & CSP evals<br>● PI on evaluation of AP participation, staffing, and training in DC Public Schools for the REL Mid-Atlantic. Impact analysis lead on the IES Impact Evaluation of Departmentalized Instruction<br>● WWC certified and has served as a quality assurance reviewer for the WWC<br>● Ph.D. in Measurement, Statistics, and Evaluation, University of Maryland; B.A., Trinity University |
| [redacted], Researcher (Mathematica) | ● Senior advisor for the EIR evaluation<br>● Consults on the research design and provides input throughout the evaluation<br>● Reviews all reports and other deliverables for quality assurance | ● PI of Uncommon's i3 and CSP evaluations<br>● Leader on multiple charter impact evaluations, incl. QED and RCT design evaluations of KIPP and the National Evaluation of CMO Effectiveness<br>● WWC certified and has served as a quality assurance reviewer, product lead, and deputy PI on the WWC<br>● MPP in Education, Family, & Social Policy, Georgetown U.; AB, Harvard College |

The CURE CompSci Management Team will receive critical support from central office staff on the Curriculum and Assessment, Data Analytics, and Marketing Teams. Appendix B provides management team resumes; Appendix J provides the CS Manager job description.

C.3. REASONABLENESS OF COSTS. Project costs for personnel, contracts, and supplies are aligned to activities and objectives and amount to a per-student cost of $469.

Table 4. Number of Students Impacted by CURE CompSci[2]

| School Year | SY22-23 | SY23-24 | SY24-25 | SY25-26 | **Total** |
|---|---|---|---|---|---|
| # of Students | 1,625 | 1,625 | 2,353 | 2,925 | 8,528 |

These costs are reasonable given the caliber of the Project Team, the contribution to public knowledge through curriculum sharing and rigorous evaluation, and the additional leverage supplied by public and private funds. Moreover, these costs represent a conservative estimate given that teachers will be able to use their knowledge and skills to support additional students after the project has concluded. Critically, EIR funds will be used to build the capacity of USI educators to sustain the project on public dollars from state and local entitlement funds at the close of the grant period. As adapted for CURE CompSci, Uncommon's proven PD model will

[2] The average sizes of USI's Grade 9 and 10 cohorts are 182 and 143 students. CURE CompSci will be implemented in Grades 9 and 10 at five Treatment Schools in SY22-23 and 23-24. Implementation will then expand to four Control Schools, starting with Grade 9 in SY24-25 and reaching Grade 10 in SY25-26 (see Section D.1).

feature: (1) a two-day Summer Institute with content differentiated by role, subject area, and returner status; (2) weekly one-on-one coaching provided by ILs that uses data to align classroom practice with student need; and (3) weekly interdepartmental STEM-CS collaborative planning periods. These systems, structures, and practices that are hallmarks of the USI model — many now adopted as best practices by school districts across the country — will both support fulfillment of the project's objectives and ensure sustainability once grant funding lapses.

C.4. FEEDBACK AND CONTINUOUS IMPROVEMENT. As detailed in Section D.1, all nine of the research questions that will guide the external evaluator's data collection and analysis efforts will be used to support continuous and iterative improvements in project design and implementation. Mathematica will collect and analyze student enrollment and performance data as well as perceptual data from surveys and focus groups annually. Each spring, the PI will present the data to the CURE CompSci Management Team during a monthly Project Team meeting and will make targeted recommendations on how the project can be strengthened prior to its full-scale impact evaluation. Under the guidance of the Project Director, Uncommon's CAT Team will revise the project's curricular components and will adjust both summer PD content and ongoing coaching protocols as appropriate. Dissemination efforts will reflect this commitment to continuous improvement as USI will continually update materials on its Curriculum Hub and will share new learnings with partners and the broader educational community.

## D. QUALITY OF THE PROJECT EVALUATION

D.1. PRODUCING EVIDENCE ABOUT PROJECT EFFECTIVENESS. A well-documented and executed randomized controlled trial (RCT) that **meets WWC standards without reservations** will provide actionable information about the effectiveness of CURE CompSci for educators and policymakers. Ongoing performance feedback will help USI determine how to modify CURE

CompSci throughout the project period, and results from the final evaluation will help educators within and outside of USI determine whether the modifications represent effective strategies.

The evaluation will directly answer the most important and policy-relevant questions about the effectiveness of CURE CompSci in improving Math, Science, and CS achievement and in making progress toward other project goals (Table 1). The first five questions assess differences between the treatment and control groups for the final evaluation and for ongoing feedback. The additional research questions will be assessed only in the treatment group for providing ongoing feedback. For each research question that is part of the final evaluation, Mathematica will analyze results for the full sample of students and separately for Black and Latinx students.

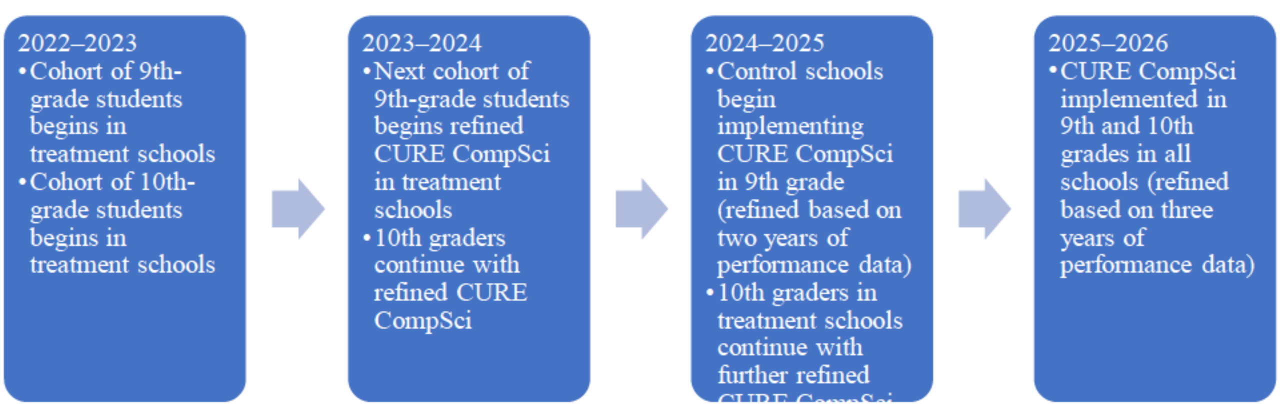
Table 5. Research Questions and Data Sources

| Research question | Data sources | Final evaluation | Ongoing feedback |
|---|---|---|---|
| 1. What are the impacts of CURE CompSci on students' participation and passing rates on AP CS exams? How do impacts differ across race and ethnicity? | AP exam data | ✓ | ✓ |
| 2. What are the impacts of CURE CompSci on students' achievement in 9th- and 10th-grade Math and Science courses? How do impacts differ across race and ethnicity? | USI Interim Assessment data | ✓ | ✓ |
| 3. What are the impacts of CURE CompSci on self-efficacy in computing? How do impacts differ across race and ethnicity? | Student survey | ✓ | ✓ |
| 4. What are the impacts of CURE CompSci on interest in pursuing CS in high school, as indicated by enrollment in CS electives, selection of CS projects, and enrollment in AP CS courses? How do impacts differ across race and ethnicity? | Course enrollment data | ✓ | ✓ |
| 5. What are the impacts of CURE CompSci on interest in postsecondary CS studies? How do impacts differ across race and ethnicity? | Student survey | ✓ | ✓ |
| 6. To what extent is the content of CURE CompSci relevant? How could it be improved? | Teacher surveys and focus groups | | ✓ |
| 7. To what extent were the teacher trainings relevant, useful, and high quality? How could they be improved? | Teacher surveys and focus group | | ✓ |
| 8. To what extent was the course instruction relevant, useful, and high quality? How could it be improved? | Student focus groups | | ✓ |
| 9. To what extent do students feel as though they belong in the CURE CompSci-embedded courses? How could the learning environment be improved? | Student focus groups | | ✓ |

**Study design.** The final evaluation of CURE CompSci will be a well-executed RCT designed and implemented by researchers at Mathematica with significant expertise in executing

impact studies that meet WWC standards (Table 3). Before collecting data, Mathematica will obtain institutional review board (IRB) approval for the study design, including data collection instruments, from either New England IRB or Health Media Lab. Mathematica will **randomly assign schools** to a treatment or control group by first grouping schools that have similar characteristics and then randomly assigning schools to the treatment or control group within each group of schools. This design will ensure the treatment and control schools have balanced baseline characteristics, including the schools' average Math and Science achievement, the percentage of students taking and passing AP CS courses, and the rate of student attrition. **No confounding factors** are expected for this RCT because the intervention is a whole-school model and multiple schools will implement the model included in the treatment group. A well-implemented RCT with no confounding factors should result in unbiased estimates of the impact of enrolling in a school offering CURE CompSci. The RCT will begin in 2022–23 with all nine high schools currently in the Uncommon network (five to treatment and four to control) and will include two cohorts of students: rising ninth graders in both 2022–23 and 2023–24. Students from all schools will eventually receive CURE CompSci; the control schools will begin implementing it in 2024–25, after each cohort has at least one year of implementation (Figure 2).

Figure 2. Project Rollout Allows for Collecting and Analyzing Data and Ongoing Refinement



**Limiting bias from attrition and joiners.** A well-designed RCT must limit overall attrition and the difference in attrition levels between the treatment and control groups at the school and student levels. Because USI will implement the intervention at the school level only in schools it operates, we can guarantee all nine schools remain in the sample, limiting the most important form of overall and differential attrition. The design will also ensure the treatment and control schools have similar student-level attrition levels by stratifying random assignment on the level of baseline attrition. As long as student-level attrition is similar during the study period as in the prior school years, this will limit the difference in student attrition rates in the treatment and control groups. In addition, including schools or students in the final sample that join the study late can pose a risk of introducing bias. If USI opens any new high schools during the study period, the final evaluation will not include them because they were not randomly assigned to treatment. Likewise, the final analysis will not include students who enroll after Grade 9.

**Ensuring baseline equivalence.** By grouping schools with similar baseline characteristics before randomly assigning them, the study team can ensure the treatment and control groups are similar in terms of schools' prior Math and Science achievement and the percentage of students taking and passing AP CS courses. We can assume any differences between the treatment and control groups on baseline characteristics are the result of chance. In its final report, the study team will provide means on prior achievement and the percentage of students belonging to each demographic group for treatment and control to facilitate a review of baseline equivalence.

**Valid and reliable outcomes.** The primary outcome measures for the final evaluation are (1) the percentage of students from the 9th-grade cohort who took an AP CS exam and 2) the percentage of students from the 9th-grade cohort who took and passed the AP CS exam.[3] These

[3] We consider performance on Uncommon's interim Science and Math assessments and self-efficacy and interest in CS to be secondary outcomes that are less likely to be the focus of a WWC review.

outcomes (1) have face validity and reliability, (2) are not over-aligned, and (3) will be collected in the same manner and at the same times annually for both the treatment and control groups.

**Estimating impacts.** Mathematica will estimate impacts of CURE CompSci on taking and passing AP exams using the following model:

$$(1) \qquad logit(y_{ij}) = \alpha_j + \beta X_{ij} + \theta T_j$$

where *yij* is the outcome of interest for student *i* in school *j*, *αj* is a school-specific intercept, *Xij* is a vector of characteristics of student *i* in school *j*; *Tj* is an indicator for random assignment to either the treatment or control group; and $\beta$ and $\theta$ are parameters to estimate, with robust standard errors clustered at the school level. In this framework, the $\theta$ term represents the impact of attending a school with CURE CompSci. To account for the different treatment probabilities for each school, the study team will weight the impact estimates based on the inverse of each school's treatment probability. Mathematica will estimate each model for the full sample of students and separately by race and ethnicity.

The study team will report impact results using traditional hypothesis testing to be consistent with typical reporting under the WWC standards so educators can compare the results to other studies reviewed by the WWC. Mathematica will also use an alternate approach to interpreting impact estimates called BASIE (BAyeSian interpretation of estimates). The BASIE approach uses Bayesian methods to directly estimate the probability that the true effect of an intervention is of a certain size.[4] This will provide educators information they can use to decide if CURE CompSci would be a good option for their school or district. For example, some educators might feel comfortable implementing an intervention if there is 60 percent certainty the results had a positive impact, but others might want a greater degree of certainty. Providing this information

[4] For example, for the outcome on percentage of students taking an AP exam, we would provide the percentage certainty that the true effect was greater than 0, 5, and 10 percentage points (Deke & Finucane, 2019).

will help educators with different criteria make decisions about implementation. Another advantage of BASIE is that it generates usable information for decision makers even when impact estimates are imprecise due to small sample sizes. This can be a challenge in a study with only nine schools; the study could have very strong, positive effects but cannot report the findings as statistically significant due to imprecision. BASIE overcomes this challenge by providing valuable information about the certainty that the study achieved positive results even when the estimated impacts from traditional hypothesis testing are not statistically significant.[5]

D.2. PROVIDING PERFORMANCE FEEDBACK & PERMITTING PROGRESS ASSESSMENT. Mathematica will collect, analyze, and provide annual feedback on an array of performance outcomes, including achievement on internal assessments in the courses in which CT units are embedded; participation and achievement in AP courses; self-efficacy and interest in CS; enrollment in CS electives and AP CS courses; and the quality, relevance, and inclusiveness of CS content and instruction. The performance feedback will incorporate three cohorts of students: 10th graders entering in 2022–2023, 9th graders entering in 2022–2023, and 9th graders entering in 2023–2024 (Figure 2).[6] Mathematica will provide annual impact estimates using the RCT design described above, along with summaries of implementation and cultural responsiveness measures so that USI can refine CURE CompSci for the ensuing year. The results from three years of implementation will inform changes for the version of CURE CompSci rolled out to all schools.

Incorporating feedback from students and teachers will be important to making culturally responsive and inclusive refinements. To be as inclusive as possible, we will collect the achievement measures, course enrollment, and student surveys from all students in the relevant

[5] With traditional hypothesis testing and 80% power, the expected minimum detectable effect (MDE) is 0.45 standard deviations. With BASIE and 80% power, the MDE with 60% certainty is 0.16 and with 75% certainty is 0.24.
[6] The 10th-grade cohort of 2022–2023 is not part of the RCT because it did not receive the full intervention beginning in 9th grade, but it can still provide valuable performance data that can inform future modifications to CURE CompSci.

grade levels in treatment and control schools. Mathematica will report the outcome measures for the full sample and separately by race and ethnicity to identify any barriers for underrepresented groups. We will administer the teacher surveys, which will provide information about implementation, to all teachers of the embedded CURE CompSci courses. The focus groups will use open-ended questions about the cultural responsiveness of CURE CompSci with a diverse sample of teachers and students in the treatment schools. The study team will conduct descriptive quantitative analyses of the survey data to identify implementation challenges encountered by teachers and qualitative analyses of the focus group data to examine common themes and areas for improvement in students' and teachers' experiences with the CURE CompSci courses.

D.3. CONTRIBUTION TO INCREASED KNOWLEDGE. Given the vast racial disparities in access to AP CS courses, postsecondary studies, and high-wage careers, underrepresented students stand to benefit from programming that systematically addresses the structural barriers preventing them from entering CS fields. Little is known about what types of interventions can reduce these disparities. A rigorous impact evaluation of CURE CompSci will contribute to the wider field of education policymaking by providing rigorous performance data and impact estimates that can guide USI and other school systems on how to implement inclusive and equitable CS programs.

In the last year of the grant, Mathematica will publish a concise report that summarizes the results from the final impact evaluation. Uncommon and Mathematica will distribute the report widely and throughout the EIR network. The report will describe the key components of CURE CompSci and the adaptations made throughout the grant period so schools outside Uncommon will have the information to replicate effective strategies. Furthermore, Uncommon will share evidence-based practices and lessons learned from the evaluation through its partnerships with community school districts and the CSGF working group.

## REFERENCES

American Society for Engineering Education, Department of Institutional Research andx Analytics (2019). *Current status of the U.S. engineering and computing workforce, 2019*. Retrieved from https://ira.asee.org/national-benchmark-reports/workforce2019/.

Basu, S., Biswas, G., Sengupta, P., Dickes, A., Kinnebrew, J., & Clark, D. (2016). Identifying middle school students' challenges in computational thinking-based science learning. *Research and Practice in Technology Enhanced Learning, 11*(1), 1–35. https://doi.org/10.1186/s41039-016-0036-2.

Bhutta, N., Chang, A. C., Dettling, L. J., & Hsu, J. W. (2020). *Disparities in wealth by race and ethnicity in the 2019 Survey of Consumer Finances.* Board of Governors of the Federal Reserve System. Retrieved from https://www.federalreserve.gov/econres/notes/feds-notes/disparities-in-wealth-by-race-and-ethnicity-in-the-2019-survey-of-consumer-finances-20200928.htm.

Brown, E. A. & Brown, R. S. (2020). *The effect of Advanced Placement Computer Science course taking on college enrollment*. West Coast Analytics. Retrieved from http://www.westcoastanalytics.com/uploads/6/9/6/7/69675515/longitudinal_study_-_combined_report_final_3_10_20__jgq_.pdf.

Burnett, A., McCullough, M., & Williams, B. (2021). *Impacts of Uncommon Schools in a turnaround setting.* Mathematica. [Attached in Appendix J].

Burnette, J. L., Hoyt, C. L., Russell, V. M., Lawson, B., Dweck, C. S., & Finkel, E. (2020). A growth mind-set intervention improves interest but not academic performance in the field of computer science. *Social Psychology and Personality Science, 11*(1), 107–116. https://doi.org/10.1177/1948550619841631.

Charleston, L. J., Charleston, S. A., & Jackson, J. F. L. (2014). Using culturally responsive practices to broaden participation in the educational pipeline: Addressing the unfinished business of *Brown* in the field of computing sciences. *The Journal of Negro Education, 83*(3), 400–419. https://doi-org.tc.idm.oclc.org/10.7709/jnegroeducation.83.3.0400.

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology, 6*(49), 1–8. https://doi.org/10.3389/fpsyg.2015.00049.

Code.org, CSTA, & ECEP Alliance. (2020). 2020 State of Computer Science Education: Illuminating Disparities. Retrieved from https://advocacy.code.org/stateofcs.

College Board (2020). *AP Program participation and performance data: 2020 national summary report.* Retrieved from https://secure-media.collegeboard.org/digitalServices/pdf/research/2020/National.xlsx.

Deke, J. & Finucane, M. (2019). *Moving Beyond Statistical Significance: the BASIE (BAyeSian Interpretation of Estimates) Framework for Interpreting Findings from Impact Evaluations* (OPRE Report 2019-35). Office of Planning, Research, and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services. Retrieved from https://www.acf.hhs.gov/sites/default/files/documents/opre/opre_brief_finucanedeke_042619_508_1.pdf.

DiSalvo, B., Guzdial, M., Meadows, C., Perry, K., McKlin, T., & Bruckman, A. (2013). Workifying games: Successfully engaging African American gamers with computer science. *SIGCSE '13: Proceeding of the 44th ACM technical symposium on computer science education*, 317–322. https://doi.org/10.1145/2445196.2445292.

Eglash, R., Gilbert, J. E., Taylor, V., & Geier, S. R. (2013). Culturally responsive computing in urban, after-school contexts: Two approaches. *Urban Education*, *48*(5), 629–656. https://doi.org/10.1177/0042085913499211.

Flanagan, B. (2019, January 30). Charter and district teachers learn side by side in Newark. *NJ Spotlight News*. Retrieved from https://www.njspotlight.com.

Flapan, J., Hadad, R., Shorall, C., & Twarek, B. (2020). CS Equity Guide: A K-12 education leader's guide to designing, scaling, and sustaining equitable computer science in California. University of California, Los Angeles. Retrieved from https://csforca.org/wp-content/uploads/2020/09/CSEquityGuide_Sep2020.pdf.

Flórez, F. B., Casallas, R., Hernández, M., Reyes, A., Restrepo, S., & Danies, G. (2017). Changing a generation's way of thinking: Teaching computational thinking through programming. *Review of Educational Research, 87*(4), 834–860. https://doi-org.tc.idm.oclc.org/10.3102/0034654317710096.

Goode, J., Johnson, S. R., & Sundstrom, K. (2018). Disrupting colorblind teacher education in computer science. *Professional Development in Education, 46*(2), 354–367. https://doi.org/10.1080/19415257.2018.1550102.

Google Inc. & Gallup Inc. (2016a). *Diversity gaps in computer science: Exploring the underrepresentation of girls, Blacks and Hispanics*. Retrieved from http://goo.gl/PG34aH.

Google Inc. & Gallup Inc. (2016b). *Trends in the State of Computer Science in U.S. K-12 Schools*. Retrieved from http://goo.gl/j291E0.

Google Inc. & Gallup Inc. (2017). Encouraging Students Toward Computer Science Learning. Results From the 2015-2016 Google-Gallup Study of Computer Science in U.S. K-12 Schools (Issue Brief No. 5). Retrieved from https://goo.gl/iM5g3A.

Guzdial, M., Ericson, B., McKlin, T., & Engelman, S. (2013). Georgia Computes! An intervention in a US state, with formal and informal education in a policy context. *ACM Transactions on Computing Education*, *14*(2), 1–29. https://dx.doi.org/10.1145/2602488.

Hammond, Z. (2014). *Culturally responsive teaching and the brain: Promoting authentic engagement and rigor among culturally and linguistically diverse students*. Corwin.

Koshy, S., Martin, A., Hinton, L., Scott, A., Twarek, B., & Davis, K. (2021). The computer science teacher landscape: Results of a nationwide teacher survey. Kapor Center. Retrieved from https://mk0kaporcenter5ld71a.kinstacdn.com/wp-content/uploads/2021/05/KC21002_-CS-Teacher-Survey-Report_final.pdf.

Kukul, V. & Karatas, S. (2019). Computational thinking self-efficacy scale: Development, validity and reliability. *Informatics in Education, 18*(1), 151–164. https://doi.org/10.15388/infedu.2019.07.

Lakanen, A-J. & Kärkkäinen, T. (2019). Identifying pathways to computer science: The long-term impact of short-term game programming outreach interventions. *ACM Transactions on Computing Education, 19*(3), 1–30. https://doi.org/10.1145/3283070.

Lang, C., Craig, A., & Egan, M. (2016). The importance of outreach programs to unblock the pipeline and broaden diversity in ICT education. *International Journal of Information and Communication Technology Education, 12*(1), 38+. https://doi.org/10.4018/IJICTE.2016010104.

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2008). *Stuck in the shallow end: Education, race, and computing.* MIT Press.

Massachusetts Department of Elementary and Secondary Education (2021). Massachusetts State Plan for the American Rescue Plan Elementary and Secondary Emergency Relief Fund. Retrieved from https://oese.ed.gov/files/2021/07/Masschusetts-ARP-ESSER-State-Plan-Final.pdf.

McIntosh, K., Moss, E., Nunn, R., & Shambaugh, J. (2020). *Examining the Black-white wealth gap*. Brookings Institution. Retrieved from https://www.brookings.edu/blog/up-front/2020/02/27/examining-the-black-white-wealth-gap/.

Morales-Chicas, J., Castillo, M., Bernal, I., Ramos, P., & Guzman, B. L. (2019). Computing with relevance and purpose: A review of culturally relevant education in computing. *International Journal of Multicultural Education, 21*(1), 125–154.

Nakajima, T. M. & Goode, J. (2020). Lighting up learning: Teachers' pedagogical approaches for make(ing) computing culturally responsive in electronic-textiles classrooms. *Computing in Science and Engineering, 22*(5), 41–50. https://doi.org/10.1109/MCSE.2020.3007164.

National Center for Education Statistics, U.S. Department of Education (2018a). Percentage distribution of school teachers, by race/ethnicity, school type, and selected school characteristics. *National Teacher and Principal Survey (NTPS).* Retrieved from https://nces.ed.gov/surveys/ntps/tables/ntps1718_fltable01_t12n.asp.

National Center for Education Statistics, U.S. Department of Education (2018b). Percentage distribution of school principals, by race/ethnicity, school type, and selected school

characteristics. National Teacher and Principal Survey (NTPS). Retrieved from https://nces.ed.gov/surveys/ntps/tables/ntps1718_21033101_a12n.asp.

National Center for Education Statistics, U.S. Department of Education (2020). Table 322.30 — Bachelor's degrees conferred by postsecondary institutions, by race/ethnicity and field of study: 2017-18 and 2018-19. *Digest of Education Statistics.* Retrieved from https://nces.ed.gov/programs/digest/d20/tables/dt20_322.30.asp.

New Jersey Department of Education (2021). New Jersey State Plan for the American Rescue Plan Elementary and Secondary Emergency Relief Fund. Retrieved from https://oese.ed.gov/files/2021/06/New-Jersey-ARP-ESSER-State-Plan_Redacted.pdf.

New York State Education Department (2021). New York State Plan for the American Rescue Plan Elementary and Secondary Emergency Relief Fund. Retrieved from https://oese.ed.gov/files/2021/08/New-York-ARP-ESSER-State-Plan-Final.pdf.

Phillips, R. S., & Brooks, B. P. C. (2017). Hour of code: impact on attitudes towards self-efficacy with computer science. Retrieved from https://code.org/files/HourOfCodeImpactStudy_Jan2017.pdf.

Pinkelman, S. E., McIntosh, K., Rasplica, C. K., Berg, T., & Strickland-Cohen, M. K. (2015). Perceived enablers and barriers related to sustainability of school-wide positive behavioral interventions and supports. *Behavioral Disorders*, *40*(3), 171–183.

Rodríguez-Martinez, J. A., González-Calero, J. A., & Sáez-López, J. M. (2020). Computational thinking and mathematics using Scratch: An experiment with sixth-grade students. *Interactive Learning Environments*, *28*(3), 316–327. https://doi-org.tc.idm.oclc.org/10.1080/10494820.2019.1612448

Sarrafzadegan, N., Rabiei, K., Wong, F., Roohafza, H., Zarfeshani, S., Noori, F., & Grainger-Gasser, A. (2014). The sustainability of interventions of a community-based trial on children and adolescents' healthy lifestyle. *ARYA Atherosclerosis*, *10*(2), 107–117.

Scott, K., Aist, G., & Zhang, X. (2014). Designing a culturally responsive computing curriculum for girls. *International Journal of Gender, Science and Technology*, *6*(2), 264–276.

Scott, K. A., Sheridan, K. M., & Clark, K. (2015). Culturally responsive computing: A theory revisited. *Learning, Media, and Technology*, *40*(4), 412–436. http://dx.doi.org/10.1080/17439884.2014.924966.

Scott, K. A. & White, M. A. (2013). COMPUGIRLS' standpoint: Culturally responsive computing and its effect on girls of color. *Urban Education*, *48*(5), 657–681. https://doi.org/10.1177/0042085913491219.

Shelton, R. C., Cooper, B. R., & Stirman, S. W. (2018). The sustainability of evidence-based interventions and practices in public health and health care. *Annual Review of Public Health*, *39*, 55–76. https://doi-org.ezproxy.cul.columbia.edu/10.1146/annurev-publhealth-040617-014731.

Taub, R., Ben-Ari, M., & Armoni, M. (2009). The effect of CS unplugged on middle-school students' views of CS. *ITiCSE '09: Proceedings of the 14th annual ACM SIGCSE conference on innovation and technology in computer science education.* 99–103. https://doi.org/10.1145/1562877.1562912.

Vallett, D. B., Lamb, R., & Annetta, L. (2018). After-school and informal STEM projects: The effects of participant self-selection. *Journal of Science Education and Technology*, *27*, 248–255. https://doi.org/10.1007/s10956-017-9721-1.

U.S. Department of Labor, Bureau of Labor Statistics (2020). *Employment projections — 2019–2029*. Retrieved from https://www.bls.gov/news.release/pdf/ecopro.pdf.

U.S. Department of Labor, Bureau of Labor Statistics (2021). Table 11 — Employed persons by detailed occupation, sex, race, and Hispanic or Hispanic ethnicity. *Labor force statistics from the current population survey*. Retrieved from https://www.bls.gov/cps/cpsaat11.htm.

Vakil, S. (2018). Ethics, identity, and political vision: Toward a justice-centered approach to equity in computer science education. *Harvard Educational Review, 88*(1), 26–52.

Vegas, E. & Fowler, B. (2020). *What do we know about the expansion of K–12 computer science education? A review of the evidence.* Brookings Institution. Retrieved from https://www.brookings.edu/research/what-do-we-know-about-the-expansion-of-k-12-computer-science-education/.

Wang, J., Hong, H., Ravitz, J., & Moghadam, S. H. (2016). Landscape of K-12 computer science education in the U.S.: Perceptions, access, and barriers. *SIGCSE 2016: Proceedings of the 47th ACM technical symposium on computing science education.* 645–650. http://dx.doi.org/10.1145/2839509.2844628.

Washington, A. N. (2020). When twice as good isn't enough: The case for cultural competence in computing. *SIGCSE '20: Proceedings of the 51st ACM technical symposium on computer science education.* 213–219. https://doi.org/10.1145/3328778.3366792.

Washington, G., Mejias, M., & Burge, L. III (2019). Attracting Black High School Boys to Computer Science Through Tech Innovation and Entrepreneurship, *2019 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 1–6. https://doi.org/10.1109/RESPECT46404.2019.8985869.

Whelan, J., Love, P., Pettman, T., Doyle, J., Booth, S., Smith, E., & Waters, E. (2014). Predicting sustainability of intervention effects in public health evidence: Identifying key elements to provide guidance. *Journal of Public Health, 36*(2), 347–351. https://doi.org/10.1093/pubmed/fdu027.

Woodworth, J. L. & Raymond, M. E. (2013). *Charter school growth and replication: Volume II.* Center for Research on Education Outcomes (CREDO). *Retrieved from* https://credo.stanford.edu/sites/g/files/sbiybj6481/f/cgar_growth_volume_ii.pdf.

Woodworth, J. L., Raymond, M. E., Han, C., Negassi, Y., Richardson, W. P., & Snow, W. (2017). *Charter management organizations*. Center for Research on Education Outcomes (CREDO). *Retrieved from* https://credo.stanford.edu/sites/g/files/sbiybj6481/f/cmo_final.pdf.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: Pedagogical approaches to embedding 21st Century problem solving in K–12 classrooms. *TechTrends, 60*(6), 565–568. https://doi.org/10.1007/s11528-016-0087-7.