Systemic Change to Improve Equity in Computer Science Student Achievement

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SIGNIFICANCE

Introduction, response to priorities, and rationale. Education Development Center, Inc. (EDC), in collaboration with the Massachusetts Department of Elementary and Secondary Education (MA DESE), the Massachusetts Association of School Superintendents (M.A.S.S.), the University of Massachusetts–Boston (Regional Partner for Code.org), and 15 urban and rural districts that serve over 10,000 students, proposes the **Systemic Change to Improve Equity in Computer Science Student Achievement** project. The intervention will implement, refine, and evaluate a comprehensive district change model that embeds computer science (CS) coursework as a required component of the curriculum for the 2500 seventh and eighth grade students in participating districts. The model—the **Programming the Acceleration of Computing and Equity Framework for CS Systems Change (PACE Framework)**—will unite urban and rural middle school district and school leaders, teachers, staff, and parents in reconfiguring their schools to prepare *all* students, including underrepresented and high-need students (defined as students who are eligible for free or reduced-price lunch, rural students, English learners, and students with disabilities), with the CS skills that are increasingly required for academic and professional success. The PACE Framework includes state- and district-level leadership commitments to sustainable systemic change; requires districtwide enrollment of *all* seventh and eighth grade students in two years of CS coursework; uses a proven inquiry-based CS curriculum and associated professional development (PD) from Code.org that is well-supported and easily scaled; engages all teachers in an intensive Equity Methods course to foster culturally responsive and equitable teaching that fully engages those students traditionally under-represented in CS; features intensive expert facilitation and evidence-based strategies to support continuous improvement of district-specific implementation and supports; and includes a dynamic

professional learning community (PLC) and other school and community supports to positively engage students, teachers, and parents in this elevated commitment to CS.

This innovative approach to accelerating equitable participation and progression in CS education by high-need students emerged from needs assessments and strategic analyses conducted by M.A.S.S. and the EDC-led Massachusetts Computing Attainment Network (MassCAN), a public-private sector alliance of statewide education stakeholders, to better understand the persistent and systemic challenges that limit the number and the diversity of students pursuing and/or succeeding in CS education. As reflected in our logic model and rationale in Appendix G, we anticipate that implementation of this model will do the following:

- Increase student achievement and interest in CS
- Elevate the quality of middle school CS teaching
- Enable more equitable participation and progression in CS education by under-represented and high-need students
- Establish strong middle school CS pathways for high school and Advanced Placement CS
- Meet the demand for a workforce with foundational CS skills and knowledge

The PACE Framework addresses *Absolute Priority 1: Demonstrating a Rationale* and *Absolute Priority 3: Field-Initiated Innovations—Promoting STEM Education with a Particular Focus on Computer Science* and the *Competitive Preference Priority.* The model integrates research-based strategies across multiple components of the intervention, which together are likely to have positive impacts on the above teacher and student outcomes and on sustainable implementation of district changes. The approach provides equitable access to high quality, culturally responsive CS instruction and supports for all students enrolled in middle schools in the participating districts, all of which serve majority high-need students (including

majority rural students). The district commitments required in the PACE model directly anticipate the challenges that districts generally face when implementing new initiatives, including poor alignment of supporting infrastructures in the system, changes in district priorities, and a lack of buy-in and ownership (Datnow, 2005; Elmore, 1996; Supovitz & Weinbaum, 2008). To embed a new curriculum and seek gains in learner achievement across an entire education system, it is essential to align policies and programs (Cohen & Spillane, 1993). We are also mindful that program implementation and effectiveness are the product of interactions between policies, people, and places and of the local context in which the initiative is executed (Honig, 2006). Consequently, the PACE model is designed to invest multiple stakeholders—district staff, instructional leaders, principals, teachers, counselors, librarians, etc.—with agency and accountability to successfully support adoption of CS as an important component of a middle school education. Our district change model integrates several elements identified in the research literature as key to organizational change (Neufeld & Roper, 2003):

- Commitment of leadership to the change process (creating processes to operationalize big ideas; inspiring and guiding stakeholders) (Corrigan & Boyle, 2003; Hodges, Hernandez, Nesman, & Lipien, 2002; Klinger, Ahwee, Pilonieta, & Menendez, 2003; Schofield, 2004; Thompson, Brown, Townsend, Henry, & Fortner, 2011)
- Creating a collaborative culture with multiple stakeholders (Joyce & Showers, 2002)
- Allocating appropriate resources to support the innovation (Fixsen, Phillips, & Wolf, 1978; Fleuren, Wiefferink, & Paulussen, 2004), and fostering commitment to sustaining change through supports and structures (Joyce & Showers, 2002)

- Aligning organizational structures to support implementation components (Blase, Fixsen, & Phillips, 1984; Fixsen & Blase, 1993; Huber et al., 2003) and achieving horizontal and vertical integration within the system (Unger et al., 2000)

The PACE Framework uses Code.org's *Computer Science Discoveries* (*CS Discoveries*) curriculum and PD, which has demonstrated effectiveness in raising student interest in CS and achievement in basic CS knowledge and skills (Bort, Guha, & Brylow, 2018; McGee et al., 2018, 2019). An Equity Methods course will center on teaching research-based strategies for equitable and inclusive teaching and learning, including an "effort based" mindset among all students (Blackwell, Trzesniewski, & Dweck, 2007), and addressing expectations that certain students are likely to perform poorly (Good, Aronson, & Inzlicht, 2003; Sherman et al., 2013). Similarly, our intensive support to districts and our dynamic PLC will use evidence-based strategies to help develop the individual and collective knowledge, structures, systems, competencies, and motivation to both teach and support the importance of CS (Bryk, Camburn, & Louis, 1999; Goddard, Goddard, & Tschannen-Moran, 2007; Louis & Marks, 1998).

Demonstrated need for innovative, alternate strategy to accelerate equitable CS education. The project represents an exceptional approach to a pressing equity challenge identified by statewide CS stakeholders seeking to accelerate participation of high-need students in high-quality CS education. Nationally, fewer than half of all schools offer meaningful CS courses that include programming (Google Inc. & Gallup Inc., 2016b). Parents, teachers, and principals cite lack of exposure to CS, limited educational opportunities, and few role models as major reasons that women and certain racial and ethnic groups are under-represented in CS (Google Inc. & Gallup Inc., 2016a). Students, parents, and educators in rural and small-town communities may express the same level of interest in CS as large city or suburban districts but have access to

fewer opportunities to learn or progress in CS education (Google Inc. & Gallup Inc., 2017). Project partners have been collaborating on state policies and strategies to change these trends in Massachusetts, co-developing a K–12 Digital Literacy and Computer Science (DLCS) Curriculum Framework (MA DESE, 2016) as a sequential guide to providing students with CS knowledge and skills that prepares them for postsecondary education and competitive careers.

The state has also created a licensure program for its new Grade 5–12 DLCS Teaching License, and is strongly encouraging its 406 school districts to implement the standards, and encouraging aspiring grade 5–12 CS teachers to become licensed. However, state leaders, superintendents, and CS education and workforce policy stakeholders alike, note the inherent weakness in the current scaling strategy, which relies on individual teachers choosing to take the PD programs necessary to offer CS courses in their schools and reach more students. Consequently, implementation of CS across K–12 has been highly variable, with inconsistent implementation and quality oversight by schools, an inequitable distribution and limited number of opportunities, and inconsistent or inadequate teacher preparation and supports, all of which contribute to persistent disparities across the state in terms of access, participation, and progression in the CS education pipeline of high-need students, as evidenced in state data (MA DESE, 2018).

The proposed PACE Framework grew out of collaborative efforts over the last two years by M.A.S.S., MassCAN, MA DESE, and statewide CS education stakeholders to address this challenge by moving beyond the nationally prevalent model of CS education as a teacher/classroom intervention to envision a district-wide systems change model with an equity strategy that better prepares diverse students to succeed. Project partners explored superintendents' receptivity to this alternate approach through a survey on districts' current engagement with K–12 CS education, pressing challenges in implementing and growing CS

education, and their interest in using a systemic approach to scaling equitable standards-based CS education in their districts. A surprisingly large group of 30 superintendents indicated interest in taking immediate steps to lead a systems change model to support a multi-year process to implement the state's DLCS Curriculum Framework in their districts. Building on this receptivity, project partners developed the PACE Framework as a way to build strong district ownership and capacity to improve equitable CS access and participation through districtwide CS planning, implementation, data gathering, and continuous improvement. Our systems change approach is grounded in the analysis of O'Day and Smith (2016) in their 50-year review of *Quality and Equality in American Education*; they argue that systemic challenges require systemic solutions, since "disparities within the educational system are the product of institutional structures and cultures that both disenfranchise certain groups of students and depress quality overall" (p. 297). The PACE Framework defines five elements (see pages 7-8) that we believe are central to improving equity and impacting diverse students' academic achievement. Although all components are key to sustainable quality, equitable teaching, and student engagement and progression, a critical feature is the commitment to provide *all* students with a common foundation of CS skills and knowledge through two sequential years of standards-based CS curriculum.

Scalable systems change model with the PACE Toolkit to support statewide replication. As noted in their letter, MA DESE is actively interested in scaling the approach and will work with EDC/MassCAN to report to state policy stakeholders and legislators. The Toolkit will provide a blueprint and resources for replication including equity-focused PD components; school, community, and family engagement strategies; and documentation of lessons learned from implementation, continuous improvement cycles, and robust PLCs. Public and private sector

leaders as well as MASS, DESE and CSTA leaders will actively engage, support, and energize districts to implement the framework with rigor and to contribute to project artifacts and lessons learned, to create a robust Toolkit to scale the approach to other districts. Project activities and outcomes will be annually reported to state legislators by MassCAN/EDC and project partners.

Contribution to the knowledge base on strategies for equitable CS implementation and supports. There is insufficient research into the required supports and systems needed to produce more equitable student outcomes in CS education. Project findings will make a significant contribution to understanding the impact of systems change strategies within a whole-district adoption model on student achievement and progression in CS. Although our intervention focuses on Code.org's *CS Discoveries* program, if successful, the PACE Framework could support a districtwide middle school adoption model with other evidence-based CS curricula and PD components. Evaluation findings can help inform the design and efficacy of related district or statewide CS adoption strategies, and the PACE Toolkit (including the Equity Methods course) could be refined to support and study whole-district or whole-school approaches to equitable K–12 CS integration.

PROJECT DESIGN

The PACE Framework provides the conceptual basis for the intervention, with a deliberate focus on middle schools, a significant transition point in students' career development and a pivotal point on their education pathway.

Table 1: PACE Framework for Districtwide Systems Change: Five Key Elements

1. *Equitable access through districtwide adoption.* Include all 7th and 8th grade students at the outset, and continually build teachers' capacity to engage and serve all students, especially under-served students. Employing equity strategies and methodologies broadens participation

in computing and promotes interest and persistence in pursuing both advanced coursework in CS and CS-enabled careers (Mark & Klein, 2019).
2. *Curriculum scope, depth, and PD.* Select a strong foundational curriculum, aligned with state standards, and provide it in sequential years (grades 7 and 8) and in sufficient depth (75 hours per year) to maximize the impact on student achievement and interest. Provide a high-quality, rigorous, and intensive nine-day PD program focusing on CS content (such as that offered by *CS Discoveries*) both prior to and during the first year of teaching.
3. *Enhanced teacher and school staff support.* Provide a three-part continuous support system that includes (a) an Equity Methods course in which teachers deeply explore research on barriers to under-served student participation, emerging best practices, and classroom materials and processes that promote engagement of all students, and (b) a robust facilitated PLC that inspires and engages educators, and includes a TA request/advice helpline within the PLC for rapid-response coaching and implementation support.
4. *Inclusive stakeholder partnerships.* Develop District Stakeholder Councils (DSCs) to lead systems change efforts within each district. Involve all stakeholder communities impacted by CS education efforts, and honor their voices and contributions. Build CS champions within stakeholder communities, and embed district efforts within the state's educational policy infrastructure to enhance long-term sustainability.
5. *Continuous improvement through data-based decision-making.* Build the capacity of district staff and DSCs to gather and use data to continually improve their efforts to meet strategic goals for CS education.

Goals, objectives, and outcomes

Project goals, objectives, and outcomes are designed to articulate and measure the extent to which the key elements of the PACE Framework for CS Systems Change are operationalized in each participating district.

Table 2: Project Goals, Objectives, and Outcomes

GOAL 1: Facilitate district change using the PACE Framework to develop a CS pathway by ensuring that all grade 7 and 8 students develop basic knowledge and skills in CS.
Goal 1 objectives: ▪ Co-develop and share the PACE Toolkit, which uses districts' visions and goals to design guidance documents for school system leaders to use as they advocate for and implement CS education. ▪ Participating districts implement PACE Framework with a high degree of fidelity as measured by the District Infrastructure Index.

- Work with each participating school system to establish a DSC representative of major stakeholder groups, that will develop, monitor, and continually improve the district/system's strategic plan for implementing a CS pathway.
- Engage the DSC in capacity-building, strategic planning, and continuous improvement activities through bi-annual Summits and DSC meetings.

Goal 1 outcomes:

- The draft PACE Toolkit is used to guide districts' CS implementation plans.
- By the end of Year 1, each district has established and met six times with its DSC. Interviews with district contacts, agenda reviews, and project reports will reveal that 90% of Council meetings include capacity-building and continuous improvement activities, including sharing data and using data to make decisions.
- Each DSC develops and annually reviews and improves its five-year strategic CS implementation plans, following the PACE Framework.
- School systems engage in systems change and develop and implement policies and procedures to ensure that all grade 7 and 8 students have opportunities to develop interest, knowledge, and skills in CS. All schools increase scores on District Infrastructure Tracking System's Capacity Index Scores. Master Schedules indicate that all seventh and eighth graders are taking *CS Discoveries*; school systems commit resources to the implementation of the strategic CS plan and to long-term support for CS education pathways; teachers volunteer/are assigned to teach *CS Discoveries*; and CS instructional resources needed for implementation are provided in all schools.

GOAL 2: Provide capacity-building PD and support of *CS Discoveries*, and equity methods to middle school teachers in school districts.

Goal 2 objectives:

- Convene a professional learning program that includes a five-day *CS Discoveries* Summer Institute and four quarterly follow-ups to build teachers' capacity to teach *CS Discoveries* content and engage students of diverse backgrounds through the teaching methods directed at broadening participation in computing. Provide participating teachers with letters to gain credit towards DLCS licensure.
- Design and convene a multi-day Summer Institute focused specifically on Equity and Diversity Teaching Methods for CS to deepen teachers' knowledge and skills and further build their capacity to engage students from diverse backgrounds in CS education.
- Provide intensive implementation support through the DSCs for a robust facilitated PLC, and a TA request/advice helpline within the PLC or rapid-response coaching and implementation support. Offer bi-weekly online PLC activities led by seasoned *CS Discoveries* facilitators and mentor teachers for all educators implementing *CS Discoveries* in participating school systems.

Goal 2 outcomes:

- 90% of *CS Discoveries* teachers become more proficient in teaching the content and practices, as measured by pre-post PD teacher surveys.
- 100% of targeted educators participate in the *CS Discoveries* Summer Institute, and 80% of *CS Discoveries* educators participate in quarterly follow-up PD sessions.

- *CS Discoveries* teachers are comfortable and confident in teaching upcoming units as documented through teacher interviews and case studies.
- 80% of *CS Discoveries* educators participate in an Equity/Diversity Teaching Methods Institute;
- 80% of *CS Discoveries* teachers seek implementation support by participating in the PLC, measured through annual interviews with PLC facilitators.

GOAL 3: Support fidelity of implementation of *CS Discoveries,* and use of equitable teaching strategies and practices, in all middle schools in each participating school district.

Goal 3 objectives:
- Teachers implement the *CS Discoveries* curriculum with a high degree of fidelity in all middle schools in participating districts.
- Teachers utilize equitable teaching strategies and practices.

Goal 3 outcomes:
- Teachers implement the curriculum with approximately 2500 from schools under-served in CS, with the majority from rural schools as demonstrated in National Center for Education Statistics (NCES) local code criteria.
- Grade 7 students develop basic CS knowledge and skills in problem-solving with computers, Web development, animations, and games. Grade 8 students develop knowledge and skills in the design process, data and society, and physical computing.
- The curriculum is implemented with 75% fidelity as measured by guidelines developed by SageFox/EDC describing program differentiation, districts' concerns, adherence, and quality of program delivery. SageFox Consulting Group evaluates CS education initiatives focused on teacher PD, curriculum development, and statewide change.

GOAL 4: Conduct rigorous evaluation of impact on student outcomes that meet What Works Clearinghouse standards with reservations, and impact on participating teachers.

Goal 4 objectives:
- Finalize recruitment of intervention districts with sufficient numbers of students to support desired power analysis.
- Collect and analyze data on students' CS achievement, interest, and progression.
- Collect and analyze data on teachers CS instructional capacity/equitable teaching practices.

Goal 4 outcomes:
- 75% of students from PACE districts will score as well or better than comparison students on *CS Discoveries* end-of-unit assessments.
- 75% of students from PACE districts will score higher than comparison students on DLCS math items on the MCAS. A sub-study will describe data on the performance of students from under-represented groups in PACE districts on DLCS math items.
- More intervention students choose continued CS education than comparison students, as measured by self-report and/or pre-registration in ninth grade CS courses.
- 90% of *CS Discoveries* teachers increase their ability to integrate instructional strategies promoting equity/diversity into their courses as measured by the Culturally Responsive Teacher self-efficacy scale and BASICS survey course implementation sub-scales.

GOAL 5: Promote use of the systems change model in adopting a whole-district approach to CS to improve the equity and impact of CS education.
Goal 5 objectives: ▪ PACE Framework design, best practices, and emerging lessons learned are shared widely via press, publications, social media, presentations, colleagues, and participant and partners' dissemination networks to generate interest in the model. ▪ PACE evaluation findings are written up and submitted to peer-reviewed journals. ▪ PACE Framework components, PD, and other artifacts and guidance documents are assembled into a draft PACE Toolkit with DSC and project Advisory Board input. ▪ The PACE Toolkit is produced and promoted via press, publications, social media, presentations, colleagues, and participant and partners' dissemination networks.
Goal 5 outcomes: ▪ Communities in which the school systems reside recognize and can identify school system champions of CS education and school system actions to promote CS education for all. PTO and other community members participate in informational meetings in 100% of districts. ▪ PACE implementation and results generate statewide and national dialogue on the value of districtwide commitment to equitable CS participation by *all* students and the need to ensure that *all* students equally participate in CS. ▪ The toolkit is used to scale the PACE districtwide middle school adoption model in other districts within Massachusetts and/or nationally. ▪ The toolkit is used to implement the PACE Framework with other robust CS curricula and PD components at the center.

PACE Toolkit. Using an iterative capacity-building development process, PACE project staff will work with DSCs at their meetings and summits to identify tool and resource needs and to develop, pilot, and refine the PACE Toolkit. Councils will use this step-by-step online resource to develop, implement, and continuously improve of their strategic plans for a middle school CS pathway. The Toolkit will include both knowledge and skill resources and a set of useful tools in the form of downloadable templates, sample meeting agendas, and presentation talking points designed to assist DSCs in their efforts to promote CS education and the PACE Framework.

Feedback and continuous improvement. The project has taken specific steps to ensure feedback and continuous improvement regarding its operations.

Table 3: Eight-Point Plan for Feedback and Continuous Improvement

1. The framework is designed around inclusion to ensure that all stakeholder groups have a position at the table and a voice in the decision-making.
2. Regular check-ins with DSC chairs will ensure open and ongoing communication between project and implementation sites.
3. Inclusive capacity-building approaches will undergird DSC meetings which will be organized around guiding questions focused on critical needs and implementation issues identified by stakeholders.
4. Shared-drive work systems (e.g., Google Drive) will be used by project staff and DSCs to produce team-generated working documents, and to contribute to and monitor progress.
5. DSCs will be trained in and use data-based decision-making for implementation decisions.
6. Councils will review and update their strategic plans annually.
7. Training and learning exchanges at bi-annual summits will ensure consistency in capacities developed by DSC members and provide opportunities to synthesize district input.
8. Evaluation activities begin early and will provide ongoing feedback to the project's leadership team through monthly update meetings with SageFox.

Project Advisory Board. Advisory Board members (see letters of support, Appendix C) bring substantial backgrounds and wisdom related to the goals of the project. The Advisory Board will meet face to face twice annually and virtually twice a year. Members include: Tom Scott, M.A.S.S. Executive Director, who played a lead role in the development of the PACE Initiative with MA DESE and EDC/MassCAN. Steve Vinter who served for 10 years as Google's Cambridge, Mass., site manager and is the co-founder and Board Chair of MassCAN. Tisha Nguyen is the Solution Professional for Microsoft over the New England region and is deeply engaged with CS leaders advancing equitable CS education. Melissa Zeitz is a K–5 teacher at Liberty Elementary School in Springfield, Mass., and current co-president of the Western Mass. chapter of the Computer Science Teachers Association (CSTA).

Dissemination plan. We will collaborate with our partners and advisors to ensure that our dissemination plan includes products and strategies to reach policy developers, researchers, practitioners, communities, and employer/industry stakeholders with a vested interest in

advancing CS education. We will tailor materials and presentations to fit each target audience, choosing the most effective format for each (e.g., research briefs, case studies, blog posts, infographics, video interviews), and leveraging the expertise of partners and participants to inform the development of products and ensure their effectiveness and cultural responsiveness.

Website, products, and social media. Our project website will provide information about PACE goals, partners, activities, lessons learned, emerging findings, and products; it will also host the password-protected PLC.

PACE Toolkit. The PACE Toolkit will include a section on Dissemination and Messaging that provides an overview of dissemination strategies (including websites, social media, presentations, published articles, and case studies) and the uses of each; talking points targeting specific audiences (policymakers, researchers, business partners, educators, parents, other community members); presentation slide decks; and other dissemination tools/materials.

Presentations. Staff and project partners will ensure that key CS and education stakeholders are informed about implementation progress, emerging findings and lessons learned, and resources through presentations at selected state, regional, and national conferences, as well as association meetings that reach policy developers (e.g., M.A.S.S., Council of Chief State School Officers, Association for Women in Computing), researchers (e.g., American Educational Research Association, National Science Foundation's Computer Science Principal Investigators and Discovery Research K–12 Project Leaders), and practitioners (e.g., American Association of School Administrators, CSTA, Education Commission of the States), and relevant organization meetings (e.g., CS4ALL, Special Interest Group for CS Education (SIGCSE)

Emerging findings and research publications. In Year 4, we will share lessons learned through articles submitted to practitioner publications, such as *Educational Leadership* (ASCD), and *AMLE* [Association for Middle Level Education] *Magazine*. In Year 5, a research article presenting evaluation findings will be submitted to a peer-reviewed journal, such as *Educational Researcher*, the *Journal of Science Education and Technology*, or the *Middle School Journal*.

MANAGEMENT PLAN

EDC has assembled a team that brings directly relevant experience and skills to their respective roles and a successful track record of leading large, complex projects focused on district change, educational research, and CS education, as reflected in their CVs (see Appendix B). The project Leadership Team will be led by PI/PD Joyce Malyn-Smith (ED IT Career Cluster, former Boston Schools central office administrator), who will ensure that project goals are met and activities are aligned. Malyn-Smith will manage partners, budgets, reports, and dissemination, and will work with Anne DeMallie (MA DESE CS/STEM Integration Specialist) to monitor district participation and to ensure that elements key to quality implementation and scaling of the PACE Framework are reflected in the Toolkit. Sarita Pillai (PI NSF STELAR, co-PI CIRCL, computer scientist) will work closely with Deborah Boisvert (Executive Director, BATEC/UMass), Anne DeMallie, and a district change expert team [redacted] to provide coaching and technical assistance for DSC meetings, cross-districts summits, and Summer Institutes; and design the PLC. Boisvert serves as Code.org MA State Partner and primary contact with Code.org national office for curriculum, PD and data. Code.org national will be responsible for Seattle-based activities. James Stanton (Executive Director, MassCAN) will lead Advisory Board meetings, co-lead summits, plan DSC activities, and assist in designing

the Toolkit. Katherine Shields (Researcher, REL-NEI) will monitor evaluation, work with the DSC to provide guidance on implementation fidelity and will develop data-based decision-making materials. The Management Plan will include bi-weekly check-ins among project staff; careful monitoring of the tasks, timelines, and deliverables by the PD and the Leadership Team; and frequent communication with the project's evaluator, who will provide monthly regular input to ensure quality control of products and processes. To ensure clarity of roles, all project stakeholders (individuals and organizations) have agreed to the following accountabilities aligned to major tasks.

Table 4: Management Matrix of Organizational Responsibilities

Responsibilities	EDC	UMass	DESE	SageFox	District*	Principal	Teacher	Code.org
1. Systems reform	PR	R	R	E	PR	P	P	-
2. PD	PR	R	R	E	R	R	P	R
3. Curriculum implementation	R	R	R	E	R	PR	R	E
4. Increase achievement/ performance	R	A	R	E	R	R	PR	E
5. Promote PACE Framework	PR	R	R	E	R	R	P	E
6. Evaluation	P	P	P	PR	P	P	P	E

Primary Responsibility (PR), Shares Responsibility (R), Participant (P), Advisor (A), Observe/Evaluate (E)

* District Level Accountability refers to District Superintendent and the District Stakeholder Council.

Activities, Responsibilities by Activity, and Milestones. Outlined in the table below are unique activities, accountabilities, milestones for each year of the project.

Table 5: Activities, Responsibilities by Activity, and Milestones

Annual activities and accountabilities (throughout the life of the project):

- Conduct bi-weekly project leadership meetings: report on development and planning activities, and provide feedback for continuous improvement (PR-EDC, R-UMass)
- Conduct two project Advisory Board meetings (PR-EDC)
- Conduct six meetings with each PACE DSC; provide capacity-building technical assistance and support on planning and implementing systems change through the PACE Framework (PR-EDC/UMass, R-District)
- Conduct two multi-district DSC summits (in May and October), convening teams of three from each school district (PR-EDC/UMass)
- Include 75-hour *CS Discoveries* courses on Master Schedules (PR-Principal)
- Implement 75-hour *CS Discoveries* courses (PR-Principal, R-UMass)
- Develop and implement the PLC (PR-EDC/UMass)
- Develop and implement the PACE Toolkit (PR-EDC/UMass, R-District)
- Implement public awareness/media campaign (PR-District)
- Gather data and conduct evaluation (PR-SageFox)
- Report findings and updates to M.A.S.S., MA and NE CSTA, Mass. Board of Education, and Education Committees of the Mass. Legislature (PR-EDC/UMass)

Annual milestones:

- Six DSC meetings held in each district
- Two DSC summits held to address elements of the PACE Framework and to achieve capacity-building and information-sharing goals
- Master Schedules set up for the upcoming year include all middle school students in a 75-hour *CS Discoveries* course (Year 1, all students in grade 7; Years 2–5 all students in grades 7 and 8)
- 2 Part *CS Discoveries* course (75 hours each) implemented in all middle schools
- PLC addresses teachers' support needs
- Findings disseminated to M.A.S.S., CSTA, Mass. Board of Education, and Education Committees of the Mass. Legislature
- Interim evaluation report produced

Year 1 unique activities (October 2019–September 2020):

- Finalize agreements with districts and choose comparison schools (PR-EDC)
- Establish PACE DSC in each district by December 2019 (PR-District, R-EDC)
- Identify and recruit grade 7 and 8 teachers and staff who will participate in the PD and teach *CS Discoveries* in 2020–21 and/or 2021–22 (PR-District, R-EDC/UMass)
- Plan and deliver *CS Discoveries* 2020 Summer Institute (PR-EDC/UMass)
- Recruit and train *CS Discoveries* facilitators to lead the PLC (PR-EDC/UMass)
- Align *CS Discoveries* curriculum to DLCS Standards, and develop CS licensure letter (PR-DESE, R-UMass)

- Co-develop with districts the draft PACE Toolkit (PR-EDC, R-UMass, R-DESE)
- Gather and analyze baseline data (SageFox)

Year 1 unique milestones:

- PACE DSCs involving all relevant stakeholder groups are established in each district
- *CS Discoveries* course (75 hours) for grade 7 is included on all Master Schedules
- *CS Discoveries* Summer Institute and follow-up PD sessions are held; PLC is established; PD activities and PLC address teachers' PD and support needs
- CS licensure letter is provide to all teachers taking PD
- Media strategy is co-designed with Councils
- Relevant tools are added to the PACE Toolkit

Year 2 unique activities (September 2020–August 2021):

- Conduct End of Year 1 Debrief, data reviews, and continuous improvement sessions with PACE Advisory Board (PR-EDC/SageFox, R-DESE, R-UMass)
- Arrange for *CS Discoveries* PD for additional grade 7 and 8 teachers as needed (PR-UMass)
- Implement Cohort 1 (grade 7) (PR-Principal)
- Develop and implement the Equity Methods course to be offered as the Summer 2021 Institute for all CS teachers (PR-EDC, R-DESE, R-UMass)
- Pilot and refine the PACE Toolkit (PR-EDC, R-District)
- Develop public website (PR-EDC, R-UMass, P-District, Principal, Teachers)
- Implement public awareness/media campaign (PR-District, R-EDC/UMass, Principal)

Year 2 unique milestones:

- Educators are trained in *CS Discoveries* curriculum and equitable teaching methods
- *CS Discoveries* course (75 hours) for all grade 7 and 8 students is included in all middle school Master Schedules for the upcoming year
- PACE Toolkit draft provides resources to DSCs
- Website shares information about CS champions and project/district activities

Years 3 and 4: See Annual activities, accountabilities and milestones

Year 5 unique activities (2023–2024):

- Conduct final data-gathering and evaluation activities; produce final evaluation report
- Produce final version of *PACE Framework and Toolkit*
- Disseminate project findings via the Toolkit and website

Year 5 unique milestones:

- Final evaluation findings are disseminated to Massachusetts and national stakeholders
- *PACE Framework and Toolkit for Districtwide Systems Change* is disseminated to all middle schools in Massachusetts
- Website is finalized and arrangements are made for two-year sustainability
- Articles are published in research journals

Resources and Commitment for Sustainability. To sustain and grow the work of this project, we have developed a Five-Point Plan.

Table 6: Five-Point Plan for Sustainability and Growth

1. *Build on prior work and interests/needs of stakeholders.* This project builds on the efforts of the PACE Initiative to develop a middle school CS pathway. This project is not an end in and of itself, but rather the next step in a process that is intended to lead to the development of a K–12 CS pathway that enables all students within a district to participate in CS.
2. *Build on existing partnerships:* a. The project will expand our partnership with MA DESE. Anne DeMallie, Computer Science/STEM Integration Specialist, is currently Co-PI with PD Malyn-Smith on a multi-year, NSF-funded, statewide computational thinking project. The proposed project deepens this partnership by integrating project activities into the MA DESE educational infrastructure. [redacted]. (See MA DESE letter of support). b. The project will build on existing work with M.A.S.S., which is committed to encouraging district participation in PACE and supporting PACE activities. c. The project draws from existing partnerships with school districts involved in the PACE Initiative, who have provided project letters of commitment (Appendix C). d. MassCAN has served as a CS leader in Massachusetts for more than five years, convening CS leaders to advise on policy, and providing PD opportunities for teachers. The Former Executive Director of MassCAN is a leadership team member. e. The project will expand our partnership with UMass Boston. [redacted]
3. *Raise visibility and create champions for PACE.* The proposed project will strengthen relationships with state policymakers and practitioners, engage CS leaders (e.g., CSTA) in project activities, create opportunities to co-lead state-level activities and events, and raise the visibility of district-level CS leaders.
4. *Provide tools and resources for sustainability and replication.* The PACE Framework guides implementation, and the PACE Toolkit provides districts with hands-on tools and resources to design and implement a CS pathway in middle schools. PACE will provide to teachers participating in Summer Institutes documentation letters for CS licensure.

5. *Use data-based decision-making for continuous improvement.* Throughout, the project will generate and review data to aid in decision-making and create opportunities to share PACE data (including data on less-resourced communities) on project findings with Mass. education policymakers and practitioners.

PROJECT EVALUATION

The evaluation is designed to (1) evaluate the fidelity of implementation and examine the factors related to successful implementation, and (2) explore the impact of PACE on outcomes at the student, teacher, and district levels. This study will produce evidence that meets the **What Works Clearinghouse's standards with reservations**. The evaluation will be led by Dr. Alan Peterfreund, [redacted]r of SageFox Consulting Group. The evaluation will seek to answer questions at the project, district, teacher, and student levels (see Tables 7 and 8).

Table 7: Levels of Evaluation Questions

1. District level:
   a. What is the difference in infrastructure devoted to CS in intervention districts vs. comparison districts?
2. Teacher level:
   a. Does teaching the course result in an increased sense of proficiency in teachers around CS course content and practices?
   b. Does participation in intervention PD and support lead to higher levels of self-efficacy to use culturally responsive teaching practices among participating teachers?
   c. Does participation in the PLC lead to sharing of CS teaching techniques and experiences among teachers?
3. Student level:
   a. Do intervention students have higher scores on relevant MCAS math items related to DLCS than students in comparison districts?
   b. How do intervention student scores on *CS Discoveries* curriculum module assessments compare to students in comparison districts?
   c. Are intervention students more likely to pursue additional opportunities to study and engage in CS in high school (where those opportunities exist) than comparison students?
   d. Within intervention districts, are students in under-represented groups succeeding and persisting in CS at the same rate as majority students?
   e. Do under-represented students in intervention districts perform at a comparable or higher level than majority and under-represented students in comparison districts?

This study will use a mixed-methods quasi-experimental design to answer the abovementioned evaluation questions. Enrollment into the treatment and comparison groups will be done at the district level. Comparison districts will be chosen based primarily on the following criteria (see Appendix I for a preliminary identification of districts):

- NCES urbanicity definition to match rural fringe districts
- Districtwide MCAS math scores
- Key student characteristics, including the overall number of students in the district, and the percentage of students in categories under-represented in CS, specifically: female students, students from under-represented minority groups, students with disabilities, and students eligible for free or reduced-price lunch.

The above information about all districts in Massachusetts will be compiled, and districts will be paired using the propensity score matching approach with nearest-neighbor matching, which will help reduce selection bias due to unmeasured factors influencing whether a student attends a treatment or comparison district school (Dehejia & Wahba, 2002). **Baseline equivalence.** We will ensure that no matched districts have a difference in average baseline MCAS scores that exceeds .25 standard deviations.

Project fidelity of implementation (FOI) tracking. FOI will be tracked primarily through the development of three tracking systems, as described in Table 8. These tracking systems will be used by the PI to inform the development of the PACE Toolkit – the primary vehicle for **project replication** (as described in detail earlier sections of this proposal).

Table 8: Three Systems to Track Implementation Fidelity

Teacher tracking system: With project leadership and Code.org, the evaluation team will assist in the creation and maintenance of a cross-district system to track teachers in both intervention and comparison districts. The system will collect background information about teachers,

including their experience level and certifications, basic demographic information, and the courses and subjects they have taught. Information in this tracking system will be supplemented by information available in MA DESE databases.
District infrastructure tracking: The evaluators will work with project leaders to create a district data tracking system to understand information about each school in the district: which unique CS courses at the high school and middle school levels (and how many sections) are being offered, how many teachers are teaching the courses (tied into the teacher tracking system), and the demographic breakdown of all students, (including race/ethnicity, gender, disability status, and free or reduced-price lunch status). This information will be compiled into a quantitative "district infrastructure index," which will be used as part of the study of district capacity building.
CS Discoveries *course FOI:* Using data automatically collected through the Code Studio platform each implementation of the *CS Discoveries* course will be rated on how closely the implementation matches the model (ensuring that implementation reaches at least 75% fidelity – **threshold of acceptable implementation**). Evaluators will work with project leadership to determine what the critical, preferred, and ancillary elements are for determining FOI; this will be turned into a metric that can be tracked from one course implementation to another. The metric will be used to help account for discrepancies in district performance and to determine if the *CS Discoveries* course is effective at broadening student participation in CS and fostering long-term engagement.

Study of district infrastructure and capacity building. To obtain a deeper understanding of PACE utilization and impacts, a multi-case study design will be used to understand the literal and/or theoretical replication issues, as PACE efforts are implemented under different conditions (Yin, 2009). A sample of approximately five districts will be chosen as case studies, and a sampling frame will be developed. Beginning in Year 1, interviews with school administrators will help evaluators understand the current condition of CS education in the district, the goals and objectives of the District Stakeholder Council and progress toward outcomes, and the impact that the PACE model and process are having on outcomes. Data on items such as (but not limited to) course availability, student recruitment, course assignment, teacher preparation, technology, and specialists will be captured, as well as data on ancillary supports such as community engagement and parental support. Questions about fidelity of project implementation will be asked, including specific questions about the *CS Discoveries* course. Interviews will be analyzed

for common and divergent themes, thick descriptions, and anonymous quotes (Miles & Huberman, 1994). [**Question 1a**]

Study of teacher PD. To provide formative feedback on the project's teacher PD offered (including the Equity Institute and ongoing academic-year support) and to understand the extent to which participation had an impact on teacher beliefs around CS education and their pedagogical approaches to teaching the class, we will administer teacher surveys throughout the year: prior to the PD, immediately following the PD, and at the end of the academic year. We will use the BASICS teacher survey (Outlier Research & Evaluation, 2017). We will also use the Culturally Responsive Teaching Self-Efficacy Scale (Siwatu, 2007) to measure teacher self-efficacy in using culturally responsive instruction. (See Appendix I for instrument details, including reliability and analysis plans.) The evaluation will also examine some elements of the PLC including the helpline and virtual PLC Through annual interviews with PLC facilitators, we will identify trends and specifically examine whether intervention teachers are seeking support and if the PLC is leading to increased CS idea sharing among participating teachers. [**Questions 2a, 2b, 2c**]

Study of student MCAS performance. MCAS scores from grade 7 and 8 students in both the intervention and the comparison districts will be collected from DESE at the end of each academic year during Years 2-4. The final dataset will include student MCAS scores on relevant DLCS items, district status (intervention or comparison), prior year's MCAS math scores, and key demographic variables[1](see Appendix I for an example of a student record). Using this information, a hierarchical linear modeling approach will be used to create a two-level linear

[1] gender, race/ethnicity, disability status, rural setting, and eligibility for free or reduced-price lunch

regression model, with students being the first level and the district being the second; this will help to account for the tendency for students within the same district to be more like one another than students in other districts. The model will use the current year's score on DLCS math MCAS items (see Appendix I) as the outcome variable to determine the extent to which treatment students are being impacted by the intervention. Grade 7 and 8 students will be analyzed in separate models. In addition, a second model will be created to determine the extent to which under-represented group status is a predictor of scores on the DLCS MCAS.

Moderators. Factors that will be controlled for in the equation include (1) participation in the intervention district, (2) prior performance indicators (e.g., math MCAS scores), (3) membership in under-represented groups, (4) prior experience with CS coursework, and (5) the district capacity index indicator. **Power.** Although, in addition to urban districts, we do not know the exact number of students who will be involved in the study, the average rural district in Massachusetts enrolls approximately 85 students per grade level in grades 7 and 8. We assume 15 treatment and 15 comparison districts, for a total of ~2,500 students per grade level for each year of data collection. For this two-level random-effects design, with treatment assigned at the district level, assuming a two-tailed test with α=.05, power = .80, outcome variance explained by differences between districts = 20%, variance explained by student-level covariates = 50%, and variance explained by five district-level covariates = 20%, the study is designed to achieve a moderate minimum detectable effect size of 0.43 (Dong & Maynard, 2013). [**Questions 3a, 3d, 3e**]

Study of student *CS Discoveries* assessment scores. We will examine end-of-unit assessment scores for students participating in the *CS Discoveries* course (see Appendix I for draft questions). This study will be conducted using a methodology almost identical to the study of

student MCAS performance described above, with the exception that comparison students will be drawn only from districts where the *CS Discoveries* course is being offered. We will not use the propensity score matching approach, as there will not be sufficient numbers of comparison students available. This set of students will be examined using a linear regression model that accounts for the same set of background characteristics and prior performance measures, as well as the years of experience their teachers have in teaching the course[2] and the FOI metric created to track the extent to which the course was implemented according to the model, using students' *CS Discoveries* end-of-unit scores as the outcome variable. **Outcomes.** This study will seek to answer whether districts in which all students partake in the *CS Discoveries* course have outcomes comparable to students in comparison districts, who are more likely to self-select into the course. [**Questions 3b, 3d**]

Study of student pathways. As a corollary to the study of district capacity-building, student persistence in CS (after eighth grade) will also be examined. Data about student participation in CS courses during their 9th grade year will be obtained with assistance from MA DESE partners for students in Cohorts 1 and 2 (data for Cohort 3 will not be available within the study window). *Persistence in CS* will be viewed as a binary outcome ("yes" if a student participated in a subsequent CS course, "no" if a student did not); the district capacity index/score, described above, will be used as a covariate to help account for the differing nature of opportunities from one district to another. This information will be used to create a multilevel logistic regression model, with *persistence in CS* (as defined above) used as the dichotomous dependent variable. Students will be considered level 1 of this model, and the district will be considered level 2.

[2] If *years of teacher experience* is a significant positive predictor of student scores, this will indicate that teachers are becoming more proficient over time

Control variables will include the moderators described in the previous student outcome studies and will also include the CS capacity index score for each student's district. This study will determine the extent to which retention in CS differs between treatment districts and comparison districts. In addition, a logistic regression analysis will be performed to determine if students from under-represented groups are being retained at different rates than individuals in majority groups. [**Questions 3c, 3d, 3e**]

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