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INTRODUCTION: ExpandED Schools is responding to the U.S. Department of Education's Education Innovation and Research (EIR) – Early Phase Grant for **Absolute Priorities 1** (Demonstrates a Rationale) **and 3** (Field-Initiated Innovations—Promoting STEM Education, with a Particular Focus on Computer Science) while addressing **Invitational Priority 1** (Personalized Learning). Leveraging ExpandED Schools' 15 years of experience designing and implementing career-connection programs for teens, the proposed project, *ExpandED STEM Options (ES Options)*, will advance national education interests by providing evidence for a scalable, accessible model designed to equip high-need high school students with STEM skills, including computer science; school and career interest; and workplace readiness skills needed for long-term success in postsecondary STEM pursuits. *ES Options* combines three promising strategies: 1) credit-bearing apprenticeships in STEM fields as part of high school coursework; 2) student-driven project-based learning, and 3) teaching internships, in which high school students cement their understanding of STEM and build their professionalism skills by teaching other students. Via a rigorous randomized control trial, we will assess the intervention's impact on 320 students across 20 high schools from the highest-need districts in New York City that serve a disproportionate number of minority students traditionally underrepresented in STEM.

A. SIGNIFICANCE: I. NATIONAL SIGNIFICANCE: There is tremendous need for models of engaging STEM-focused, work-based learning that can grow and diversify the talent pipeline for STEM jobs, especially those in computer science. The U.S. will add an additional 2.6 million STEM jobs to the labor market by 2024, with the largest growth in computer occupations and engineering (Bureau of Labor Statistics, 2017). Previous models of STEM preparation have not been effective at creating a STEM workforce as diverse as our country's population. While black and Hispanic individuals represent 27% of the overall U.S. workforce, they account for only

16% of the *STEM* workforce, and only 14% of the computer science workforce (Pew Research Center, 2018). This unbalanced representation in STEM fields affects our nation's overall talent pipeline and our capacity to solve society's critical problems.

Attitudes and expectations developed during high school strongly influence future aspirations (Zarrett et al., 2006) and are key in postsecondary decisions related to STEM careers. Deeper application and authentic STEM tasks make these fields attractive as viable future career options (Sadler, Sonnert, Hazari & Tai, 2012; Hsu, Roth, Marshall, & Guenette, 2009). Youth in low-income communities have particularly limited opportunities for real-world career exposure in STEM. In the New York City region, only 20% of youth ages 16-19 were employed in 2012 (Sum et al., 2014), and rates of disconnection from school and work were three times higher among black and Hispanic youth than white and Asian youth (Ross & Svailenka, 2016) and ten times higher in the lowest-income communities (e.g., South Bronx) compared to wealthier communities (Burd-Sharpes & Lewis, 2012). Thus, developing a model that can increase STEM engagement, skill development, and workforce preparation to increase and diversify our nation's future STEM leaders is of great national significance. Further, effective models must offer sustainable and scalable solutions for students from low-income communities to receive student-centered, applied learning opportunities and meaningful work opportunities.

II. PROMISING STRATEGIES: Our hypothesis is that the combination of **three promising strategies** - 1) credit-bearing apprenticeships in STEM fields as part of high school coursework; 2) student-driven project-based learning, and 3) teaching internships - will significantly increase student interest in STEM, keep students engaged and motivated to persist in school, and prepare them for college and careers in STEM majors and fields, including those in computer science and engineering. While research evidence demonstrates the potential of each of these strategies

individually, their combination as a seamless intervention that can be implemented at scale with measurable impacts for mainstream public high school students offers a critical innovation for the field. **Credit-bearing, STEM-focused apprenticeships** offer school-connected learning set in real-world contexts, which makes academic content more accessible and increases engagement in school (Wonacott, 2002). **STEM-focused, student-driven, project based learning (STEM PBL)** is an instructional approach whereby students apply abstract STEM concepts to real-world contexts, using the practices and tools of scientists. In *ES Options*, PBL consists of hands-on, student-driven activities during apprenticeships that require communication and collaboration with peers. In line with ***Invitational Priority 1****, Personalized Learning,* it is hypothesized that these student-driven projects will serve as a critical learning experience advancing post-secondary success by increasing students' abilities, beliefs and motivation for STEM disciplines. **Teaching Internships** offer high school students employment opportunities that build necessary skills for college and careers (i.e., leadership, communication, collaboration, problem-solving, time management and organization) while allowing them to solidify the content knowledge gained during the apprenticeship by teaching it to others. These employment opportunities are targeted to STEM fields (notably computer science and engineering), are accessible to minority groups underrepresented in STEM, and are scalable across U.S. through partnership with STEM-rich non-profit organizations as apprenticeship partners and funding from workforce investment and summer youth employment programs.

III. RATIONALE: The three core strategies that make up the pillars of the *ES Options* model each have strong evidence of effectiveness based on high-quality research findings. A 15-year random assignment study in nine urban high schools nationwide revealed strong benefits for **credit-bearing apprenticeships.** Youth who participated in school-based career programs

combining academic and technical curricula around a career theme earned 11% more per year on average when entering the workforce than youth in the non-academy group, with results even more substantial for men of color, who saw a 17% increase in earnings per year (Kemple & Willner, 2008). Similarly, a meta-analysis of 53 studies of *STEM-focused* apprenticeships found positive impacts on interest in STEM careers and intentions to pursue STEM education after high school, especially for minority students (Sadler, Burgin, McKinney, & Ponjuan, 2010). Research also demonstrates that **STEM-focused, student-driven, project based learning (STEM PBL)** is associated with increased self-efficacy and confidence in STEM disciplines, which in turn leads to more positive attitudes towards STEM and continued pursuit of STEM professions (Massa, 2009), especially in groups most underrepresented in those fields (Cerezo, 2015). Further, participation in STEM PBL is associated with a lower likelihood of dropout from STEM courses and increased interest in pursuing STEM careers (Berk et al, 2014). And, research documents the benefits of **teaching internships** as well. People learn and recall more when they think they will need to teach material to someone else, suggesting they have engaged in more effective learning strategies (Nestojko, Bui, Kornell, & Bjork, 2014; Roscoe & Chi, 2007; Topping, Peter, Stephen, & Whale, 2004). Meta-analyses document that impacts are especially strong among minority students and students from urban, low-income areas, with gains larger in math and science than reading programs (Rohrbeck, Ginsburg- Block, Fantuzzo, & Miller, 2003). Through teaching, students grow their leadership, collaboration, self-confidence, and communication skills, all necessary skills for long-term college persistence and career success.

IV. EXCEPTIONAL APPROACH. *ES Options* serves schools in low-income districts where nearly 80% of students are living in poverty -- providing teens in low-income NYC communities with STEM learning experiences that keep them engaged and motivated to stay in school and

pursue STEM careers. While summer jobs and internships are long-standing approaches to career exposure and healthy engagement of youth, these experiences are often disconnected from in-school study and career mapping and are not offered to enough students from low-income communities to meet national job demands. Research indicates that jobs-only youth employment programs are successful in engaging youth in short-term work, but do not affect their longer-term employment outlook (Hossain & Bloom, 2015). Moreover, most STEM career development programs do not include the application of skills to teach younger students, despite clear evidence of the benefits of doing so. The *ES Options* program provides opportunities for partnerships between schools and non-profit organization to offer youth-centered, project based learning experiences that can increase underrepresented youth interest and engagement in STEM while also building the skills needed for completing high school and planning for their post-secondary lives. Through internships, participants gain self-awareness of how they and others learn, build their own confidence as 'STEM experts,' and become active participants in their own learning. Lastly, the *ES Options* model not only provides work-based learning experiences, but via teaching, hones participants' professionalism, leadership, communication and collaboration.

B. QUALITY OF PROJECT DESIGN.

I. LOGIC MODEL OF GOALS, OBJECTIVES, & MEASURABLE OUTCOMES. *(See Appendix G)* **Hypothesis:** Our hypothesis is that the combination of three strategies: 1) credit-bearing apprenticeships in STEM fields; 2) student-driven, project based learning, and 3) teaching internships will increase students' interest and engagement in STEM, keep them engaged and motivated to persist in school, and prepare them for college and careers in STEM majors and fields. **Inputs:** ***Schools (20):*** *ES Options* will serve 20 NYC public high schools recruited primarily from the seven highest need districts in the Bronx and Brooklyn (based on

students at risk of educational failure, with a focus on students living in poverty; see Table 1). These two boroughs also have the highest youth unemployment rates within the city (U.S. Census Bureau, 2014-15). All students will be recruited from high-minority schools, defined by the NYC LEA as schools in the top quartile of proportion of students who are American Indian, Asian, Black, Pacific Islander, Hispanic, or Two or More Races. All schools will serve a disproportionately high percentage of students with disabilities, English language learners and students in poverty.

Table 1. *ES Options* Target District Profiles (Source: 2018 Demographics NYC DOE)

	NYC Citywide	Bronx Districts				Brooklyn Districts		
Demographics	**Avg**	**7**	**8**	**9**	**12**	**16**	**17**	**19**
% Asian	16%	1%	6%	1%	3%	2%	3%	8%
% White	15%	1%	6%	1%	1%	3%	4%	2%
% Black & Hispanic	66%	96%	86%	96%	94%	93%	91%	88%
% SWD	20%	23%	23%	22%	22%	25%	18%	20%
% ELL	13%	17%	14%	23%	20%	5%	11%	13%
% Poverty	74%	92%	83%	92%	91%	84%	81%	87%

Students (320): At the start of each full cohort year, students will be encouraged to attend a recruitment session. At least 20 students per school will be targeted for the session each year, after which all interested students will be invited to apply to participate. It is estimated that at least 14 students per school (total: 280 students/year) will apply. Of those, 8 students per school/year (total: 160 students/year) will be randomly selected to participate in *ES Options* while students not selected will serve as the comparison group (total: 120 students/year). The same process will occur in a second year for Cohort 2[1]. Therefore across the two cohorts, there will be a total of 320 students participating in the treatment and 240 students randomly assigned to the comparison group. ***Educators (20)***: To award credit, participating high schools must

[1] Note: All students who apply for Cohort 1 make up the study sample; therefore students who are randomly assigned to the control group in Cohort 1 will not be eligible to apply for Cohort 2.

nominate a subject-certified teacher to oversee the initiative by meeting regularly with students, reviewing final assessments, and inputting credit on students' transcripts. As such, at each school, one educator will participate each year. ***Managing Partner:*** ExpandED Schools is a not-for-profit 501(c)(3) corporation founded in 1998. ExpandED's mission is to give disadvantaged students more opportunities to develop their talents; more support to overcome the challenges of poverty; and more time to achieve at the high levels essential for success in the global workplace. ExpandED provides ongoing support and technical assistance to partners to promote high fidelity of implementation. ***Apprenticeship Partners (6):*** Apprenticeship hosts design and deliver credit-worthy, STEM-focused apprenticeship courses of at least 60 hours, support youth through successful completion of the program, and work with principals and teachers to ensure the awarding of credit. They also ensure successful placement at internship sites. Partners will include: Beam Center, New York Hall of Science, NYU Tandon School of Engineering, Mentoring in Medicine, City Parks Foundation, and Educational Video Center.

Evaluator: The Research Alliance for New York City Schools (the Research Alliance) is an independent evaluator housed at New York University and will conduct the research on *ES Options*. The Research Alliance strives to advance equity and excellence in education by providing nonpartisan evidence. ***See Appendix C for Memoranda of Understanding (MOU).***

Activities: ***Phase 1 Activities: Piloting and Refinement: Oct 2018-Aug 2019***

With an eye towards continuous improvement and iterative development, the first 11 months of the project will be devoted to the piloting and refinement of both the model and the evaluation tools used to assess its impact in subsequent years. Phase 1 will conduct a trial implementation with a subset of schools and partners. Lessons from Phase 1 will be used to make necessary

adaptations before launching the full implementation (subject to a randomized control trial) to increase its likelihood of fidelity of implementation and successful impact.

School Recruitment and Selection: A partial cohort of ten school partners will pilot the model in Phase 1. ExpandED Schools will conduct targeted outreach to principals, community leaders and superintendents across the high-need districts identified in Table 1. Principals must approve the course syllabi and agree to grant a high school credit upon completion of the program. They must also identify a subject-certified teacher to oversee the initiative and to serve as the *ES Options* liaison to assist with recruitment and coordination with apprenticeship partners. Certified teachers ensure the curriculum meets the needs and interests of students and credit-making requirements. During the program, they will closely follow students and ensure adherence to program requirements and perform weekly reflections with them. To assess performance, assign final grades, and award credit, they will attend students' final presentations or hold portfolio review sessions.

Student Recruitment and Selection: Students will be recruited via information sessions at schools. Staff will distribute flyers in multiple languages to recruit students from diverse backgrounds and will encourage students to attend the info sessions. Teachers will also conduct targeted outreach to recruit cohorts of students that mimic the demographics of each school. Students ages 16 and up will be able to apply. Those who submit an application will be invited to attend an open house at the apprenticeship location, after which they will be asked to confirm their interest and ability to commit to the full program. This three-step process will pilot the recruitment efforts that will be needed for randomized assignment. In total 8 students per school (total: 80 students) will be selected. Based on historical trends in our high school programs, we anticipate ~25% of students to be in 10th grade, 50% in 11th grade, and 25% in 12th grade.

Project-based Apprenticeships: 60 hours/year @1-2 days/week for up to 15 weeks: During the pilot year, a partial cohort of three apprenticeship partners from some of the city's premiere science and educational organizations will participate. They will be matched with 3-4 of the selected schools, serving 20-35 students each across the schools. They will provide at least 60 hours of credit-bearing STEM-focused project-based learning opportunities after school and/or on weekends. Students will learn and practice fields of study and work such as: computer science, engineering design, mathematics, botany, inquiry-based science, and digital design alongside master practitioners (see Table 2). Apprenticeships hours also include practice teaching, where students lead classrooms of younger students and receive feedback before their summer internship. Upon successful completion of apprenticeships, students earn one credit from their school and are eligible for the summer internship program.

Paid Summer Teaching Internships: 150 hours/summer: We will place the spring 2019 apprenticeship participants in internship sites for 150-hour, STEM focused teaching internships during the summer of 2019. Summer camp staff will supervise interns while apprenticeship partners provide continued coaching to students through site visits and group-building events. Paid summer internships will take place at NYC DOE-funded summer learning sites, Community School summer camps, Department of Youth and Community Development-funded summer camps, museum programs, and parks/recreation programs.

Implementation Fidelity and Continuous Improvement Activities: 25 hours/year: To ensure high fidelity to the model and continuous improvement for all apprenticeship partners, ExpandED Schools will lead a Peer Learning Community with activities throughout the year including a two-day Curricula Institute each Fall, Learning Community Meetings three times a year to guide programs, check in with staff and establish best practices, a "Step-back and Share"

meeting at the end of each summer to share promising strategies/lessons learned, intervisitations between apprenticeship sites to learn best practices from one another, and year round collaborative planning through phone calls, emails and site visits providing technical assistance to apprenticeship partners. Further, specific to Phase 1, during the Spring/Summer of 2019, ExpandED will conduct interviews and focus groups to help refine protocols for school and partner engagement, student applications and placements, and monitoring implementation in preparation for the launch of the first full cohort.

Phase 2 Activities: Cohort 1 Full Implementation (Sept '19-Aug '20) and

Cohort 2 Full Implementation (Sept '20-Aug '21)

Phase 2 involves the implementation (and assessment of impact) of *ES Options* across two full-sized cohorts, one per year. Activities in Phase 2 will mirror those in Phase 1 with respect to student participation in both apprenticeships and internships. However, there will be three key differences from the pilot phase: (1) **Additional School Recruitment**: The official Cohort 1 implementation will occur across a full sample of 20 schools, scaled up from 10 in the pilot. Schools who previously participated in the pilot will be given the opportunity to participate. An additional ten schools will be selected from a competitive application process (or more if an original pilot school opts to discontinue participation or is deemed unfit based on learnings from the pilot about requirements for successful implementation). As with the pilot phase, ExpandED Schools and apprenticeship partners will conduct targeted outreach to school principals, community leaders, and district superintendents across the high-need districts identified in Table 1. Schools will be subject to the same requirements previously identified in Phase 1 (and any additional criteria identified during the piloting phase). (2) **Additional Student Recruitment and Random Assignment** (Total: 280 students/year: 160 in treatment; 120 in control): Each of

the 20 schools will identify cohorts of 14 students ages 16 and up who have not yet participated in *ES Options* and are interested in participating. In the full implementation year, randomized selection will occur. Eight of the 14 students who express interest will be randomly selected to participate while the remaining 6 students will serve as the control group. Students selected to participate in *ES Options* will then participate in the apprenticeship and internship activities outlined in Phase 1. (3) **Apprenticeship and Internship Partner Scale Up**: In line with the scaled up school and student sample size, the official full implementation in Cohorts 1 and 2 will occur across a sample of 6 apprenticeship partners. All six apprenticeship partners will deliver STEM-focused apprenticeships as described in Table 2, four of which will involve the explicit learning and application of computer science skills.

Table 2. Summaries of Apprenticeships, PBL Activities, and Teaching Internships
New York University Tandon School of Engineering - Center for K-12 STEM Education
Apprenticeship: Students learn computer science skills needed to engineer and code a device to accomplish specific tasks. Adapted from NYU Interactive Telecommunications Program curricula on Physical Computing and Mechanical Systems, the apprenticeship comprises a series of sequential, scaffolded lessons that emphasize hands-on demonstrations, experiments and projects. Apprentices learn and learn to teach basic STEM principles, theories and technical skills related to: computer science, circuitry, electronics, mechanical systems, physical computing, and robotics. ***STEM PBL Activities:*** Apprentices complete project-based assignments, which culminate in a final design project and presentation where they are challenged to engineer a device that accomplishes a specific set of tasks to benefit the common good. **Internship:** During the summer students work at NYU Tandon School of Engineering or with summer camps teaching middle school students the basic computer science and engineering skills needed to create interactive electronic devices.

New York Hall of Science: Inquiry- based Science
Apprenticeship: Apprentices learn how to use creativity, logic, and problem-solving skills to design and construct solutions to engineering challenges from Design Squad. They learn STEM-practice foundations and advance to learn basic computer science skills needed to design and program robotic devices. ***STEM PBL Activities:*** Each week Apprentices are presented with increasingly difficult design challenges to solve. To create a solution, they must apply the STEM skills learned in previous weeks. They have the opportunity to coach museum visitors through design challenges. **Internship:** Interns work over the summer as design instructors, teaching elementary school students basic STEM principles.
Beam Center: Maker Mathematics in Context
Apprenticeship: Apprentices develop and explore projects of their own choosing using a variety of STEM concepts. At the center of their work is the application of core engineering, computer science, and mathematical concepts. They learn to use vector graphics and modeling software to design and produce 3D objects on digital fabrication equipment such as a laser cutter, 3D printer, or vinyl cutter. They also learn how logic, algebra, geometry and simple number sense are an integral part of the design process. ***STEM PBL Activities:*** Apprentices use Beam Center's Makerspace to create projects of their choosing incorporating STEM principles learned throughout the apprenticeship. A series of project questions guides their design process. **Internship:** Interns work in summer camps to teach younger students design principles through craft lessons, often using materials created during the apprenticeship.
Mentoring in Medicine
Apprenticeship: Apprentices learn to become digital health advocates by developing user-friendly programs that increase health literacy by educating users about health disparities and disease prevention. They learn fundamentals of critical thinking, scientific inquiry, computer science and interface design to produce a mobile app using *App Inventor* – a visual coding environment created by MIT and Google with data sets provided by the National Library of Medicine and NIH, learning an appreciation for data structures and logic in an interactive format. ***STEM PBL Activities:*** For their final project students are challenged to select a health issue and create an app that addresses the issue. Students research user interface design and health disparities

and present final projects to their community. **Internship:** Over the summer, interns will be able to teach the computer science concepts necessary to create apps with middle schools students.
Educational Video Center
Apprenticeship: Apprentices design an interactive website and remix archival footage while learning about a community issue. They engage with a range of web-based tools while gaining mastery of the technical skills needed to use Adobe Elements. Technical skills are translated into creative digital arts projects requiring an understanding of the workflow needed for digital designs, and organizing and processing information in new ways. ***STEM PBL Activities:*** Apprentices create a website that serves as the portfolio of their work. The website will prove student's mastery of digital media skills. They present their portfolio at final presentations to members of their community. **Internship:** Interns will work in Parks Department Recreational Computer Centers coaching peers through the process of using media art technology to create a website.
City Parks Foundation
Apprenticeship: Apprentices use Central Park Foundation's community gardens to explore industrial and local food production, nutrient and waste cycles, biodiversity, and the effects of anthropogenic changes in an urban environment. ***STEM PBL Activities:*** Apprentices work individually or in pairs to complete projects that add to the sustainable design of their garden site (i.e. installing solar panels, creating an irrigation system, designing a compost system). **Internship:** Interns teach garden-based STEM concepts to younger youth at community gardens.

Goals, Outputs & Outcomes: ***Goals:*** The project goals are to provide high school students with STEM-focused work-based learning experiences beyond traditional classrooms that (1) increase their interest and engagement in STEM, increase their knowledge of and interest in pursuing a career in a STEM field, and help them develop critical workplace readiness competencies (i.e., leadership, communication, collaboration, critical-thinking, time management and organization);

and (2) keep them engaged and motivated to stay in school and prepare them for college and career, with a focus on STEM pathways. The long-term goal is to equip high-need students with the STEM skills and sustained interest to compete for and succeed in 21st century jobs. ***Outputs:*** (1) 20 NYC public schools participate; (3) 20 educators participate; (3) 320 students participate (160/year); (4) 60 hours of participation in apprenticeships/student (5) 150 hours of participation in internships/student; (6) 2 policy and practice briefs; (7) 5 end-of-year research reports. ***Outcomes:*** aligned with short-term project goals, are: (1) Students participating in *ES Options* will demonstrate statistically significant increases in the following that surpass those seen among students in the control condition: (a) interest and engagement in STEM, (b) knowledge of and interest in pursuing STEM careers, and (c) workplace readiness competencies; (2) Relative to students in the comparison group, students participating in *ES Options* will demonstrate significantly greater: (a) school day attendance in high school and (b) preparedness for college and career as evidenced by an increased likelihood of taking a STEM or computer science-focused AP course following participation in *ES Options*, scoring higher on standardized science and math assessments and being significantly more likely to pursue post secondary education relative to students in the control group. The outcome aligned to the long-term project goal is that more high-needs, traditionally underserved students will enter the STEM workforce equipped with the skills necessary to succeed in 21st century careers.

II. MANAGEMENT PLAN

Partners/Key Personnel Roles *(See Appendix B for resumes of key personnel).*

Managing Partner (ExpandED Schools): will design and manage the project, including: school recruitment and selection; design and delivery of professional development; coordination between project partners; and dissemination of results (See Table 3).

Table 3. ExpandED (Managing Partner) Key Personnel and Responsibilities	
Candace Brazier Thurman, *Director of ExpandED Options*	Ms. Brazier Thurman will provide daily coordination of all aspects of the initiative to ensure implementation fidelity, including school and student recruitment and continued participation, continuous improvement changes, and ongoing partner management.
Deborah Taylor, *Program Manager*	Ms. Taylor will provide ongoing support to schools and apprenticeship partners to maximize implementation fidelity. She will refine tools used by schools to grant credit and provide feedback to partners on curriculum development and teaching pedagogy.
Katie Brohawn, *Vice President, Research*	Dr. Brohawn will serve as the liaison between schools and the external evaluator to facilitate data collection/evaluation activities. She will be the first point of review and feedback for all memos, reports and documents shared by the external evaluator.
Saskia Traill, *Senior Vice President*	Dr. Traill will oversee the initiative, supervise staff, ensure practices are sustainable and scalable, and will contribute to products for dissemination, including policy and practice briefs.
Emily-Jane Miranda Valdez, *Director, Communications*	Ms. Miranda Valdez will oversee dissemination activities to share initiative updates and results via ExpandED Schools' robust communication channels (see Dissemination plans).

ExpandED Schools has a proven track record of bringing together schools and community organizations to provide connected, engaging learning opportunities for students, especially those at risk of becoming disconnected from school. ExpandED Schools has designed and implemented multiple career-connection programs for teens. We began in 2003 when we were asked to administer an emergency program to provide summer jobs to 1,000 low-income NYC youth. The resulting *New York Times Summer Jobs Program* continued under our management through summer of 2011. Encouraged by the positive impact of the program, in 2006, ExpandED Schools designed and launched the City Connection after-school program. Together, these programs provided more than 6,000 high school-aged youth with summer jobs and over 400 at-risk teens with year-round work in after-school/summer youth programs. These programs also spawned a succession of successful ExpandED Schools-operated programs for high school students, including the After-School Apprenticeship Program (ASAP) which created apprenticeships in which teens learned skills and content, which they taught to younger kids.

Evaluator (The Research Alliance for New York City Schools): The Research Alliance will conduct an independent evaluation of the project's implementation and impacts (See Table 4). See evaluation section for qualifications of the evaluation team.

Table 4. The Research Alliance (External Evaluator) Key Personnel	
Dr. James Kemple, Executive Director	Dr. Kemple will provide senior oversight of all aspects of the evaluation, including the partnership with ExpandED; impact research design and implementation study. He will play a lead role in the execution of the impact analysis and oversight of reports, presentations and other public materials.
Dr. Zitsi Mirakhur, Co-investigator	Dr. Mirakhur will provide oversight and guidance on the implementation and process study, and will play a lead role in producing reports and presentation on the implementation findings.

b. Timeline and Milestones

Table 5. *ExpandED STEM Options* Timeline and Milestones		
PHASE ONE: Project Piloting and Refinement (Oct '18-Aug '19)		
Category	**Milestone**	**Due**
Evaluation	Evaluation plan finalized; application for proposed evaluation activities submitted to NYC DOE and NYU IRBs for approval	Oct-Nov
Implementation	Partial cohort of 10 schools selected from competitive application process and youth recruitment begins	Oct-Nov
CQI	ExpandED facilitates 2-day Curricula Institute: partners share promising strategies, ensure program aligns to academic standards, and work as a group to overcome shared hurdles	Oct
Implementation	Open houses at apprenticeship sites held	Nov-Dec
CQI	ExpandED facilitates 3 Learning Community Meetings designed to foster fidelity to program model and share best practices	Dec,Mar, May
Implementation	Student selection by ExpandED and apprenticeship partners	Early Jan
Implementation	Students participate in 60+ hours of apprenticeships; Teachers of Record begin periodic check-ins; ExpandED Program Manager visits sites to ensure fidelity to program model	Late Jan-Early June
Implementation	Internship sites for summer placements are confirmed	Mar-May
Implementation	Participants begin to match with summer camp placements and begin on-boarding process with summer job hosts	May-Jun
Implementation	Students participate in 150-hour, paid summer internships	July-Aug
CQI	Step-Back-and-Share: End of summer partner meeting to reflect on lessons learned and share promising strategies. Reflections and feedback inform adjustments for the coming school year	Aug
Evaluation	Pilot testing of data collection instruments and site visits to selected schools and partners to collect data on pilot implementation; survey of partial cohort of students about initial	Spring/ Summer 2019

	application process and apprenticeship placement	
Evaluation	Updates made to data collection instruments and research design; memo on pilot program implementation; design changes submitted for approval to NYC DOE and NYU IRBs	Later Summer 2019
PHASE TWO: Full Cohort Implementation *activities repeat each year for 2 years (Cohort 1: Sept '19–Aug '20; Cohort 2: Sept '20-Aug '21)		
Implementation	Refine protocols for school and partner engagement, student applications and placements, and monitoring implementation	Sept
CQI	ExpandED hosts partners for an introduction / planning meeting	Oct
Implementation	Additional school partners confirmed (total 20) and youth recruitment begins; Information sessions and application period	Oct
CQI	ExpandED facilitates 2-day Curricula Institute	Oct
Implementation	Open houses at apprenticeship sites held	Nov-Dec
CQI	ExpandED facilitates 3 Learning Community Meetings designed to foster fidelity to program model and share best practices.	Dec,Mar, May
Implementation	Student selection by ExpandED and apprenticeship partners followed by randomization by external evaluator	Early Jan
Evaluation	Randomization of selected students by external evaluator	Early Jan
Implementation	Students participate in 60+ hours of apprenticeships; Teachers of Record begin periodic check-ins; ExpandED Program Manager visits sites to ensure fidelity to program model	Late Jan-Early June
Evaluation	Collection of baseline data, consent forms, and student contact information for Cohort 1; baseline equivalency analysis	Jan-Feb
Evaluation	Evaluator conducts field research w/ subsample of five schools/ partners collecting data on implementation successes/challenges	March-Aug
Implementation	Internship sites for summer placements are confirmed	Mar-May
CQI	Intervisitions among apprenticeship partners to see 3 peers in action. These events showcase a partner that is implementing a part of the model well as an example others can learn from	Mar-May
Implementation	Participants begin to match with summer camp placements and begin on-boarding process with summer job hosts	May-Jun
Implementation	All program partners invited to attend culminating showcase of apprenticeship participants	May
Evaluation	Online survey of apprenticeship hosts re: apprenticeship activities and content, and implementation supports/challenges	June
Implementation	Students participate in 150-hour, paid summer internships	July-Aug
CQI	Step-Back-and-Share: End of summer partner meeting to reflect on lessons learned and share promising strategies. Reflections and feedback inform adjustments for the coming school year	Aug
Evaluation	Post-program surveys and data collection re: participation and completion of apprenticeships and internships; Survey of internship hosts re: implementation successes and challenges	Late August
Evaluation/ Dissemination	End of year Evaluation Reports from Research Alliance -Y2 Report: providing information on baseline equivalence testing for Cohort 1, and preliminary findings on program	Dec 2021

	implementation, including recommendations for improvement -Y3 Report: summarizing implementation and impact findings for Cohort 1, recommendations for improvements, and baseline equivalence testing for Cohort 2	Dec 2022
CQI	ExpandED research staff reviews evaluation reports to identify implementation challenges and make mid-course corrections	Dec
PHASE THREE: Post-participation outcomes tracking (Sept '21 – Aug '22)		
Evaluation	Evaluator conducts post-secondary follow-up survey of Cohort 1 students (18 months after scheduled HS graduation)	Dec
Evaluation	Evaluator conducts implementation and impact analysis for Cohort 2; integrates findings from Cohort 1 and 2; produces paper summarizing impact and implementation results for Cohorts 1 and 2 and implications for policy and practice	Aug
Dissemination	ExpandED produces policy brief highlighting results, lessons learned and/or best practices is distributed to the field	July
PHASE FOUR: Reporting and Dissemination (Sept '22 – Aug '23)		
Evaluation	Evaluator administers post-secondary follow-up survey for Cohorts 1 and 2 (for students scheduled to graduate in '21)	Dec
Evaluation	Evaluator produces final report on post-secondary impacts for Cohorts 1 and 2 and implications for policy and practice	Aug
Dissemination	ExpandED produces policy brief highlighting results, lessons learned and/or best practices is distributed to the field	Aug

III. PERFORMANCE FEEDBACK AND CONTINUOUS QUALITY IMPROVEMENT (CQI) Performance feedback and continuous improvement are integral to the project design. As described in Table 5, in addition to the initial 11-month piloting/refinement phase, the project has opportunities for structured feedback and CQI integrated throughout. At least quarterly calls with partners, project managers will discuss program implementation and identify ways to support high fidelity implementation. ExpandED will define clear expectations that all partners regularly communicate to ensure opportunities for feedback and troubleshoot issues as they arise.

IV. DISSEMINATION MECHANISMS: ExpandED will develop and disseminate work products to share implementation experiences, results and lessons learned from *ES Options*. Work products include: two policy and practice briefs, five research briefs by the Research

Alliance and at least five informal updates (e.g., blog posts, infographics) disseminated via ExpandED's substantial social media presence (Twitter: 7,500 followers, Facebook: 3,500 followers, blog: 3,500 visitors per month and e-newsletter: 6,500 readers). We will submit at least two proposals per year to present at conferences and educational forums and on webinars, with relevant groups such as the National STEM Learning Ecosystems, National Science Teachers Association, and American Educational Research Association.

C. QUALITY OF PROJECT EVALUATION. KEY RESEARCH QUESTIONS. The Research Alliance will conduct an independent evaluation of the project's implementation and impacts. The impact study will examine *ES Options'* effect on critical links in the logic model by addressing the following ***Key Impact Research Questions***: What is the impact of the *ES Options* on (1a) student interest and engagement in STEM and computer science, (1b) knowledge of and interest in STEM careers, (1c) workplace readiness, (2a) high school engagement and achievement, and (2b) post-secondary enrollment? The implementation study will provide necessary context for interpreting impact findings and offer formative feedback to program operators to make mid-course adjustments and refinements by addressing the following ***Key Implementation Research Questions***: (1b) to what extent is the program implemented with fidelity to the model? (2b) What are the facilitators and challenges to implementing *ES Options* and to sustaining its operation at high levels of fidelity? The implementation data will allow for exploration of the relationship between implementation and impacts, in order to draw conclusions about effective strategies suitable for replication or testing in other settings.

EVIDENCE STANDARDS/METHODOLOGY. The external evaluation is designed to provide formative information that will drive program improvements, and summative information that will generate knowledge about practices that improve student outcomes. The

impact evaluation will use a student-level randomized control trial design, which will produce evidence about the project's effectiveness that meets What Works Clearinghouse (WWC) Standards, without reservations. The Research Alliance will randomly assign approximately 60% of accepted applicants to the *ES Options* program (the treatment group) and 40% to the control group. This allows the program to serve more students, while sufficiently powering the study to detect small to moderate effects. Treatment group students will participate in *ES Options.* Control students will be exposed to "business as usual" conditions. This may include other internship/workplace skill-building opportunities offered to high school students. Schools will sign an MOU indicating their commitment to the project and its evaluation requirements.

Study sample: All schools will enroll a minimum of 14 students in the program starting in the '19-20 school year, and a second cohort of 14 new students in the '20-21 school year. Parents/ guardians will be asked to give consent for their child's participation in the evaluation, including allowing them to complete annual surveys and for the evaluators to gain access to NYC DOE administrative data[2]. All consented students will remain in the sample throughout the study, regardless of their participation status. Using contact information obtained at the consenting phase, researchers will reach study participants through email, text and phone messages to collect online survey data. Small incentives for data collection participation of students in the control group (and in post-program year follow-up data collection for students in the treatment group) will be offered to maximize response rates. The Research Alliance will collect high school administrative record data for all students in the study sample as long as they remain enrolled in a NYC public school (including charters). It is expected that records will be obtained

[2] The Research Alliance has a well-established partnership with the NYC DOE, including a formal Data Use Agreement that gives them access to a wide range of data for research purposes. As part of their commitment to the wellbeing of NYC students, they take the utmost care in safeguarding their data archive and protecting students' privacy. All physical data storage is securely maintained by NYU.

for at least 95% of students in the sample through the end of their 11th grade year and for 90% through the end of their 12th grade year. The Research Alliance will collect post-secondary enrollment data from the National Student Clearinghouse and the City and State Universities of New York, through their data sharing agreement with the NYC DOE. The project's time span will allow for the collection of follow-up data through the 2021-22 school year.

In keeping with WWC Standards, the evaluator will test for baseline equivalence between students randomly selected to participate in *ES Options* and those assigned to the control condition. The evaluation team will test for compositional differences in attrition rates from the participating schools and the NYC public school system between treatment and control groups. Based on the findings, recommended adjustments will be made to analysis models.[3] The table below presents minimum detectable effect size (MDES) estimates, reflecting possible impacts on student achievement measured with standardized achievement assessments. The highlighted cells show the MDES estimates for our target sample configuration, which includes a total of 20 schools and 14 students in each school per year. With the exception of the post-secondary enrollment outcomes, we will have two cohorts of students in the sample (cohort 1 starting in 2019-20 and cohort 2 starting in 2020-21).

Minimum Detectable Effect Sizes[4]		**Response Rate**	
# of Schools	# of Students per School	100%	80%
20	14	.217	.245
	16	.203	.225
	28	.153	.173

[3] What Works Clearinghouse, Procedures and Standards Handbook (Version 2.1). http://ies.ed.gov/ncee/wwc/pdf/reference_resources/wwc_procedures_v2_1_standards_handbook.pdf

[4] MDES estimates were calculated using Power Up! Software http://web.missouri.edu/~dongn/PowerUp.htm Dong, N. and Maynard, R. A. (2013). MDES estimates assume a significance level of 0.05, statistical power of 0.8, and that 60% of variation will be explained by covariates.

The table indicates the ability to detect impacts as small as .217 standard deviations (SD) if obtaining data for all students in the sample, for each cohort. Impacts as small as .245 SD can be detected if 80% of students offer data. Combining students from both cohorts in our analyses increases our sample to 28 students/school, yielding an MDES of .153 to .173. Prior research on ExpandED's[5] interventions suggests that impacts on achievement in the .30-.40 range are feasible and suggests that impacts on student engagement are likely to be considerably larger (Russell, Mielke, Miller, & Johnson, 2007; and Reisner, White, Russell, & Birmingham, 2004).

Assessment of Outcomes (Impact Study Data): The impact study will provide valid and reliable performance data on the key outcomes of interest. Through its ongoing data sharing agreement with the NYC DOE, the Research Alliance will collect the following data for all students in the study (treatment and control): *Background Characteristics*: race/ethnicity, gender, age, special education status, English language learner status, and eligibility for free or reduced price lunch. *High School Achievement Outcomes:* student attendance, AP STEM and computer science test taking and state science and math exam scores. *Post-Secondary Outcomes.* Enrollment and persistence in post-secondary institutions (via the National Student Clearinghouse and City and State Universities of New York data systems). In addition, the Research Alliance will administer yearly pre and post surveys to all treatment and control students to measure student outcomes.

***Assessment of Mediators*: Student engagement and interest in STEM,** mediating factors that lead to improvements in student achievement and post-secondary outcomes, will be measured through items adapted from the *Common Instrument* (Cronbach's alpha: 0.92) which asks students about their engagement, career plans, and feelings towards science. **Interest in computer science education and careers** will be measured through survey items adapted from

[5] f/k/a/ The After-School Corporation or TASC

the validated *Student Computer Science Attitudes Survey* (Haynie & Packman, 2017).

Workplace readiness competencies will be assessed by adapting the *NY State Workforce Too*l to create questions that ask students to rate their competencies in areas aligned to the state's *Learning Standards for Career Development and Occupational Studies,* including: work quality, initiative, response to supervision, cooperation with others, taking responsibility for learning, observing critically, decision making, problem solving using math and use of technology. It will also ask students to report on post-secondary plans (i.e. college enrollment, anticipated major).

The first student survey will be administered upon enrollment in the study providing a baseline measure (i.e., Jan '20 for Cohort 1, Jan '21 for Cohort 2). The second survey will be administered at the end of the program year (Aug '20 for Cohort 1, Aug '21 for Cohort 2). The third survey will be an 18-month post secondary follow-up to those students who have graduated high school during the implementation period. Researchers will administer a survey to June '20 graduates in Dec '21 and to June '21 graduates in Dec '22.

Assessment of Replicability (Implementation Study Data): The implementation study, which will take place over the full course of the project, will explore measures of: 1) student participation; 2) quality and intensity of professional development and support provided by ExpandED to apprenticeship staff; and 3) challenges and facilitators in implementation. To assess implementation and provide ongoing feedback to inform program improvements, we will use a variety of data sources. *Enrollment and participation data*: Sites will record student-level attendance into an online platform provided by ExpandED Schools and shared with the Research Alliance. *Annual online survey of school-based program staff and partners:* To collect uniform data across all sites about the services and supports provided to students in the programs, the Research Alliance will conduct a brief online survey of school-based program staff and partners

at the end of each program year regarding the key components of the apprenticeships and internships including the STEM and computer science content covered and expected student outcomes, and implementation challenges and supports. *Annual Site Visits and Interviews with Project Staff:* Research Alliance staff will conduct site visits to five *ES Options* programs during each year of the project. Sites will be purposefully selected to represent a range of partners and demographic characteristics of students in the program. Site visits will allow evaluators to gather in-depth and nuanced implementation data, including observing project-based learning first hand, and probe findings from program staff and student surveys. Data collection will include interviews with project staff, observations of program activities and focus groups with students. Interviews will focus on challenges staff face in implementing the program and sustaining student participation as well as areas for improvement. Focus groups will explore students' experiences with the program, including perceptions on whether and how their experience has affected their interest and engagement in STEM, their workplace skills and their post-secondary plans. Field researchers will use semi-structured interview protocols and focus groups, with transcripts coded and analyzed using Atlas.Ti Qualitative Data Analysis and Research Software.

The evaluation will assess whether the project meets fidelity to its ***implementation thresholds***: at least 85% of apprenticeship sites will offer 60 hours of programming; at least 85% of internship sites will offer 150 hours of programming; students attend 85% of apprenticeship and internship hours. Thresholds will be revisited throughout the project to ensure that inputs are robust enough to reasonably expect the hypothesized outcomes on interest, engagement, achievement and post-secondary success and to determine if measurable thresholds for implementation have been identified to support replication in other settings beyond NYC.

Evaluation Reports: The Research Alliance will produce five briefs with key findings relevant to the key stages of the program's implementation and students' participation, as follows: *Year 1:* Results from the piloting phase, lessons learned, and updates to data collection instruments and research design; *Year 2:* Information on the baseline equivalence testing for Cohort 1, program implementation, and recommendations for improvement; *Year 3:* Implementation and impact findings for Cohort 1, recommendations for improvements, and baseline equivalence testing for Cohort 2; *Year 4:* Impact and implementation results and implications for policy and practice; *Year 5:* Post-secondary impact results and implications for policy and practice.

QUALIFICATIONS OF THE EVALUATOR. The Research Alliance has a strong, successful track record managing large, complex research projects. They have led more than 30 major studies; presented findings via numerous conferences, forums and published reports; and promoted the use of data and evidence in decisions made at the school and district level. The evaluators on this project have designed and led numerous implementation and impact studies of STEM and computer science initiatives, including: (1) a nine-year study of NYC's *CS4All* initiative; (2) a three-year NSF-funded study assessing educator integration of computer science into science instruction; (3) a three-year i3-funded development project with ExpandED focused on engineering design instruction; and (4) several related studies of the implementation and impact of interventions on NYC students' career and work-related learning experiences, social and behavioral competencies, high school graduation, and transitions to college and the labor market.

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