Smithsonian Science for the Classroom:
Improving Student Achievement Across State Borders and State Standards

An Early-Phase Grant Proposal prepared by

Smithsonian Science Education Center

Submitted to

The U.S. Department of Education

Office of Innovation and Improvement

Education Innovation and Research

Project Narrative

Absolute Priority

The Smithsonian Science Education Center (SSEC) will address **Absolute Priority 1 – Demonstrates a Rationale and Absolute Priority 3 – Field-Initiated Innovations—Promoting Science, Technology, Engineering, or Math (STEM) Education**. By supporting elementary school teachers to teach engineering and science in their classrooms with aligned, differentiated professional development and research-based curricular materials, we will inspire students to one day enter the Science, Technology, Engineering, and Math (STEM) workforce and solve the complex problems that face our world. Targeting more than 11,250 students in two states (North Carolina and South Carolina), the **SSEC** will provide the necessary supports to help schools that serve a rural, high needs student population to address the changing science standards and promote high-quality, student-centered science and engineering instruction in elementary classrooms.

The United States is a global leader, in large part, due to the genius and hard work of its scientists, engineers, and innovators. Yet today, that position is threatened as comparatively few American students pursue expertise in the STEM fields—and by an inadequate pipeline of teachers skilled in those subjects. This reality is particularly true among elementary school teachers, who are typically required to complete only one instructional methods course focused on science before earning their certification, and report feeling underprepared and overwhelmed when faced with a classroom of grade school science students (Allen, 2006).

It is critical that large-scale efforts are undertaken immediately. The statistics are staggering and innovation is mandatory. Only 16% of American high school seniors are proficient in mathematics and interested in a STEM career. Less than half of those who go on to pursue a college major in the STEM fields choose to work in a related career (U.S. Department of Education, 2015). The United States is falling behind internationally, ranking 35th in mathematics and 25th in science among industrialized nations based on the Program for Student International Assessment (PISA) in 2015. In our competitive global economy, this situation is unacceptable. If the United States is to hold a competitive edge in a rapidly changing world, **bolstering the nation's STEM workforce is essential**. The Brookings Institution (Rothwell, 2013) predicts that up to 80% of the jobs in the future will require basic STEM competency even if the job is not considered a STEM career. The nation needs to connect students to jobs of the future by re-engaging them in these important fields. Preparing teachers to support these students with training in inquiry-based STEM instruction is crucial to success.

In order to address the critical need of preparing and inspiring students to pursue STEM disciplines beyond secondary school, states across the country have been taking a hard look at existing science standards and have begun making needed changes. These new standards, based on the *Framework for K-12 Science Education* (National Research Council, 2012) and the Next Generation Science Standards (NGSS), set a high bar of interdisciplinary science content that integrates the science and engineering practices that will help students excel at communication, critical thinking, and collaboration skills. Regardless of the career they pursue later in life, these skills are important for students to master. This shift in standards, together with a lack of focus on science or engineering in recent years particularly at the elementary school level, has left many districts, schools and teachers underprepared to bridge the gap between where students are and where states want students to be academically. This gap provides opportunities to create innovative programs that will provide support to districts, schools, and teachers. **The SSEC has the capacity and knowledge to fill this gap.**

The SSEC is recognized nationally and internationally for the quality and impact of its work on the improvement of K-12 STEM education as it pertains to the implementation of hands-on, inquiry-based STEM education programs. To help teachers address the changing standards, the SSEC has developed a new line of curricular materials entitled *Smithsonian Science for the Classroom.* These field-tested elementary school modules were built from the ground up to provide students with the opportunity to engage in investigating phenomena and solving problems as scientists and engineers do. Curriculum alone is not enough, however. Differentiated, ongoing professional development for teachers that supports both pedagogy and content is also needed to help teachers hone innovative strategies for scaffolding student learning in a manner different from how it has been traditionally taught. This intervention will improve student achievement for all students, including those from high needs backgrounds (defined as students with backgrounds that are traditionally underrepresented in STEM fields including racial and ethnic minorities, students in rural local education agencies (as defined in 84 FR 1085), and students who participate in free or reduced school lunch programs (FRL), which is our focus. In addition, this intervention will allow us to compare student achievement between a state that has updated their science standards, as is the case with South Carolina in 2014, and a state that has not, like North Carolina since 2010.

A. Significance (up to 25 points)

(1) The potential contribution of the proposed project to increased knowledge or understanding of educational problems, issues, or effective strategies.

A world-class education system is critical to preserving economic security and dynamism in the United States. Well-educated students and a well-educated workforce drive innovation, economic growth and prosperity. Yet in terms of innovation, the United States is falling behind. According to the 2018 Bloomberg Innovation Index, the United States ranks 8th overall, behind countries like South Korea, Sweden, Germany, Finland and Israel.

Effective inquiry-based STEM education is, in itself, an innovation engine, and more urgently needed now than ever to address such major issues as climate change, international and national security, conservation of resources, disease epidemics and other health threats, trade and more. Yet despite decades of efforts to raise standards in science education, the academic performance of students in the United States lags behind that of other developed nations. In fact, in international tests of literacy, math and science, American students consistently rank far below nations such as Finland and South Korea. These data are supported by the court of public opinion. Based on a 2015 Pew Research Center Report, only 29% of Americans believe that this country's STEM education is above average or the best in the world. This result was mirrored in a survey of the members of the scientific community. This survey indicated that 46% of the members of the American Association for the Advancement of Science (AAAS) believe that K-12 STEM in the U.S. is below average. Taken together, American students are leaving school without the math and science skills needed for jobs in the 21st century.

The Smithsonian Science Education Center is well positioned to face this challenge in collaboration with state STEM education nonprofits and the districts they serve. Founded in 1985 as a collaboration between the Smithsonian Institution and the National Academy of Sciences, the Smithsonian Science Education Center (SSEC) was tasked with transforming the teaching and learning of science across the country and around the world. Originally called the National Science Resources Center (NSRC), in 2013 the name was changed to the Smithsonian Science Education Center. The Smithsonian Institution is the largest research, education and museum complex in the world whose mission is to increase and diffuse knowledge (for an organizational chart see Appendix I). Through the SSEC, the Smithsonian takes that spirit of curiosity to spark discovery in America's classrooms every day. The SSEC uses inquiry to change how K–8 classrooms look, feel, and work. The SSEC helps the nation's teachers rekindle the yearning to discover and learn. Deep relationships with **teachers** and exceptional **professional development connected to**

classroom practice, are changing the forecast of success for students, educators and public stakeholders.

Our educational philosophy is straightforward, revolutionary and research-oriented. The SSEC's long standing history of success with the implementation of a research- and best-practices approach to science education supports the interdisciplinary strategy necessary in the STEM disciplines today. The volume of content and skills that teachers are asked to teach students each year is untenable when taught in isolation. Teachers need the tools and resources to teach more efficiently and help students achieve their fullest potential. The SSEC's newest portfolio of curricula, called *Smithsonian Science for the Classroom*, was developed based on the Next Generation Science Standards utilizing the most up to date education research. These modules will provide teachers with the resources to inspire students to solve real-world problems that face us today. These resources, when tied with differentiated ongoing professional development, provide a scaffold for sustained student learning across STEM disciplines together with critical literacy skills. This will provide an opportunity to change students' attitudes, improve outcomes, and connect learning to future employment through the STEM disciplines. Students will become engaged in generating hypotheses, designing experiments, seeking solutions, and communicating their results. There is tremendous urgency to these goals. **America and all nations recognize the economic need for a scientifically literate citizenry and workforce to take on 21st-century global challenges.**

With Early-phase funding, the SSEC will implement *Smithsonian Science for the Classroom: Improving Student Achievement Across State Borders and State Standards* as an approach for improving student achievement in science, engineering, math and reading. Built upon the strengths and lessons learned from over 30 years of educational and science expertise, the duration of **this**

initiative will reach more than 11,000 students and 300 professional educators.

The single most important factor in the academic proficiency of a student is his or her teacher (Rivkin et al., 2005). Unfortunately, the preparation for elementary school teachers in traditional pre-service programs requires only one three-credit hour course in science. Such a minimal requirement results in teachers feeling unprepared and uncomfortable in teaching science. In fact, based on a 2012 Horizon Research survey of science and math teachers, only 39% of elementary school teachers feel prepared to teach science. This number drops to 4% when the same teachers were asked if they felt prepared to teach engineering. Despite these staggering numbers, elementary school teachers are not given the training they need as in-service teachers. In the same research survey only 4% of elementary school teachers reported having the opportunity to participate in more than 35 hours of subject-specific professional development over a three-year period. Clearly there is a gap between need and opportunity, specifically for elementary school teachers in science and engineering.

Professional development alone is not the answer. Teachers cannot merely receive professional development without the resources to implement the skills and practices they need to be successful. Professional development is most effective in changing a teacher’s instructional methods, and ultimately student achievement, when the training is tied directly to classroom practice. We can achieve this direct tie by providing teachers with research-based curricular materials after attending professional development. In addition, professional development for teachers cannot be offered in a “one and done” scenario, which is all too often the reality in many school districts. To change instructional practice in classrooms, scaffolded support needs to be provided in an ongoing manner in order for teachers to hone skills and expertise in transitioning their teaching practice to novel pedagogies such as the implementation of three-dimensional teaching as described by the NGSS.

(2) The extent to which the proposed project involves the development or demonstration of promising new strategies that build on, or are alternatives to, existing strategies.

Why isn't the U.S. a leader in STEM education? The answer, we believe, is that elementary school teachers are not given the training and resources to provide robust STEM experiences for their students. A student's confidence level in their ability to perform well can impact their student achievement, which is particularly true in science (Bandura, 1997; Britner & Pajares, 2006). Elementary school is a critical time for students to develop this sense of self including students' perceived aptitude for STEM disciplines. In part, students formulate their identity through exposure to engaging experiences both in and out of school. There are many reasons that these opportunities have not been provided to students, ranging from a lack of financial resources, a dearth of human capital with science and or engineering expertise in education, or a focus on other content areas in elementary school. According to the U.S. Department of Education (2011-12), public school principals reported that third graders spent 2.9 hours on science in an average week, which was half of the hours spent on mathematics (5.8 hours) and less than a third of the time spent on reading/language arts (9.9 hours). Engineering was often ignored in the minimal amount of time allotted to science in elementary school. This is due, in large part, to the fact that until more recently most states did not explicitly include engineering in traditional science standards.

The educational landscape, however, is shifting. With the passing of the Every Student Succeeds Act (ESSA), science has become more of a priority and states are including STEM in their improvement plans. In addition, many states are updating their state science standards to reflect the *Framework for K-12 Science Education* (National Research Council, 2012) that incorporated the corpus of knowledge about science teaching and learning. The *Framework* sets a high bar for student proficiency by outlining the performance expectations for all grade levels K-12 as a driver for the standards themselves. The *Framework* set a foundation for the NGSS that describe three dimensions of learning, which include disciplinary core ideas, science and engineering practices, and cross cutting concepts. These three dimensions gird the performance expectations in an integrated manner so that content cannot be separated from the skills that drive science and engineering innovation, which is a departure from traditional science standards. The higher bar set by the three-dimensional approach to teaching will be a difficult one to achieve for districts not previously focused on science education. Historically if science and engineering were taught, they were taught as a series of facts from a textbook or techbook. This approach does not inspire or engage students with the content and ultimately provides a false representation of the nature of science and engineering.

The method to combat this gap in skills and knowledge in elementary school is to address the skills and knowledge of the most important factor in student achievement: teachers. We propose that providing robust research-based curricular materials in partnership with differentiated professional development will be a game changer in rural, high-needs districts. A particular focus on engineering and the supporting science content and skills will expose students to engaging learning experiences that will increase content knowledge and skills in all students. This premise is based on a body of research in professional development indicating that if done correctly, professional development can change teachers' instructional practices and lead to positive increases in student achievement.

There has been a great deal of research done on professional development for teachers. Some key characteristics have emerged from the research. One of these key ideas is that deepening content knowledge alone does not significantly improve student achievement, but content training tied to classroom practice or pedagogical content knowledge has demonstrated significant impacts for students (Shulman, 1986, 1987; Daehler et al., 2015; Taylor et al., 2016). Taking this one step further, teachers who can correctly identify student science content misconceptions have larger student gains than teachers who are only able to identify the correct answer (Sadler et al., 2013). Finally, effective teacher professional development is ongoing in nature to impact sustainable student outcomes (e.g. Lee et al., 2017).

Building on this body of knowledge, we propose a model of tiered professional development tied to classroom practice in an ongoing manner. The progression of professional development will occur over four years of the project for teachers in treatment schools. The first training will focus on an engineering curriculum module. As a differentiator to some engineering modules available currently, this module integrates the science content that students apply with the engineering process. Additionally, the modules are three-dimensional in nature so in the first year teachers will learn about the pedagogy and implementation of the module during the training (referred to as “curriculum-tied PD” in Table 1). After attending training, teachers will receive the curriculum module and materials to teach in their own classroom along with student notebooks. Once back in classrooms, teachers will gain ongoing support from the SSEC via a teacher leader at each school called a site coordinator. The site coordinator will be identified in partnership with school level leadership in each participating school and will be provided the flexibility in their schedule to support other teachers in their school.

When teachers return for the second summer of professional development workshops, they will be asked to bring student notebooks with them. The focus of the second summer will be specific to the content but through the lens of understanding student misconceptions (referred to as “content-tied PD” in Table 1). Teachers will have an opportunity to experience the content as learners in three-dimensional classrooms so that they can translate that experience to their teaching. They will also be building off their shared experience in teaching the modules in their classrooms the previous school year and identify student misconceptions using the student notebooks as artifacts. With a focus on student understanding teachers will be able to deepen their own understanding in a safe, learner-centered environment in order to model best practices that they can bring back to their own classrooms. Site coordinators will continue to support the implementation of the curriculum modules and supporting pedagogies in an ongoing manner through the duration of the grant timeline.

The third and fourth summers will be similar to years 1 and 2 (refer to Table 1), but this time teachers will continue their experience with a science-focused module. The science content in the second module will relate to the science in the previous module they taught, but the focus will not include an engineering challenge as an outcome; instead the outcome of the module will culminate in the students engaging in a science challenge. This training will continue to hone the skills of the teachers by deepening their pedagogy and content knowledge with a focus on student misconceptions.

In the fifth year, teachers who have excelled in the first four years of training and demonstrated an interest and capacity for leadership will be trained as trainers. These teacher trainers will then have the skills necessary to train teachers in their own local area thus building local capacity in order to sustain the project beyond the term of the grant.

Table 1: Brief overview of professional development workshop focus.

Year 1 (2019-2020)	Year 2 (2020-2021)	Year 3 (2021-2022)	Year 4 (2022-2023)	Year 5 (2023-2024)
Curriculum-tied PD engineering module (T)	Content-tied PD (T)	Curriculum-tied PD science module (T)	Content-tied PD (T)	Curriculum-tied PD engineering module (C)

Key: (T)=Treatment; (C)=Control

With over 30 years of experience in improving science education in the United States, the SSEC believes that this model of professional development together with curricular materials for engineering and science will create positive impacts for all students, particularly those in high needs, rural areas. Even so, we cannot do this work alone. It is only through the support of the infrastructure and resources of the Smithsonian Institution, together with state and local partners like the North Carolina Science, Mathematics, and Technology Education Center (NC SMT) and South Carolina's Coalition for Mathematics & Science (SCCMS) that we can hope to sustainably effect change. The approach to engineering and science education where teachers facilitate students to solve real-world problems like "How Do We Get Freshwater to Those in Need?" and "How Do We Provide Energy to People's Homes?" is innovative and long overdue. Preparing elementary school teachers to provide a venue for students in classrooms to solve the problems of today will help lay a foundation to empower students to solve the problems of tomorrow.

B. Quality of the Project Design (up to 35 points)

(1) The extent to which the goals, objectives, and outcomes to be achieved by the proposed project are clearly specified and measurable and (2) The extent to which there is a conceptual framework underlying the proposed demonstration activities and the quality of that framework.

As previously indicated, teachers are the most important influence on student achievement. The goal of this project is to provide teachers with ongoing professional development in conjunction with research-based curricular materials to provide the support necessary to bolster student learning. The measured outcome of the work is the increased student achievement for high needs, rural students in North and South Carolina in science, reading, and/or math. The professional development will be differentiated to scaffold the adult learning as described in the previous section. The goals, objectives and outcomes of this project are outlined in the logic model found in Appendix G and will be measured as described in the evaluation plan found in Table 6.

An important differentiator between North and South Carolina are the state science standards that drive science teaching on a district and school level. In North Carolina the state science standards have not been updated since 2010 and predate the publication of the National Research Council's (NRC) release of the *Framework for K-12 Science Education.* Whereas in South Carolina, the current state science standards were updated in 2014 and took into account the scaffold presented in the *Framework* and the NGSS. The *Framework* and the NGSS represent the most up to date research on how students learn together with consideration for how science and engineering is approached by practitioners in our changing world. These documents were developed through a two-step process. First the *Framework* was created by the NRC followed by the development of the NGSS through a collaborative effort of 26 lead states together with top science and education organizations such as the NRC, AAAS, and NSTA. The NGSS provided the conceptual framework for the development of the *Smithsonian Science for the Classroom* modules and the supporting tiered professional development. Given that state science standards provide the scaffold for student learning within a state and district support is driven by state standards, we will evaluate the difference in student learning using this conceptual framework across state lines to begin to understand what, if any, impact the difference in standards may have on student learning through the use of NGSS-aligned instructional materials.

The NGSS-aligned instructional materials we will be implementing as part of this project are modules entitled *"Smithsonian Science for the Classroom".* *Smithsonian Science for the*

Classroom is designed to be a comprehensive core science program for grades 1 through 5. The NGSS Performance Expectations (PEs) are divided into four “bundles” that correspond to four modules in each grade. The modules are further organized into four topical “strands”: life science, Earth and space science, physical science, and engineering design. There is one module in each strand per grade level. While the strands serve as organizing themes, the modules themselves are interdisciplinary and always include PEs from at least one other topic.

The module titles are all phrased as questions (see the curriculum matrix in Appendix I). These questions serve to engage students and tie together the concepts within the module’s PE bundle. The questions for the life, Earth, and physical science modules invite students to construct scientific explanations for natural phenomena, while the questions for the engineering design modules invite them to design solutions to practical problems. All modules have a culminating challenge—a science challenge or design challenge, depending on the strand—that serves as a performance assessment.

(3) The adequacy of procedures for ensuring feedback and continuous improvement in the operation of the proposed project.

Plans for monitoring performance feedback are outlined in the evaluation section below. The plan includes multiple feedback loops to continuously gather student- and program-level data, along with feedback from students, teachers, administrators, parents and other stakeholders. Feedback loops are based on the **Implement-Measure-Learn (IML) model** and will continuously gather performance feedback through weekly communication among project leadership, along with formal and informal communication among site coordinators and participating school districts and schools (monthly at a minimum) and Advisory Board meetings. Each region will provide feedback for a Quarterly Status Report (**QSR**) to the evaluator. The QSRs will summarize assessment data and performance feedback (formal and informal) gathered during the previous quarter. The evaluation team will analyze and summarize this information to prepare a comprehensive project-wide QSR that will present preliminary findings and summarize perceived trends apparent in the data analysis. Qualitative data gathered during the previous quarter will be analyzed using an inductive approach, which will allow the evaluator to: (a) condense the raw textual data into a brief, summary format; (b) establish clear links between the evaluation and the summary findings derived from the raw data; and (c) develop a framework of the underlying structure of experiences or processes that are evident in the raw data.

Project leaders will review QSR data and performance feedback each quarter, taking note of trends revealed through data analysis. Should any deficiencies be noted, the Project Director will place the item (or items) on the agenda for further discussion. Leadership and regional advisors will review the data, discuss and approve strategies to refine, strengthen and improve the project approach as appropriate. This ongoing review and refinement process will therefore ensure continuous improvement. An experienced, external Advisory Board (Table 2) will support project leadership in carrying out proposed activities. The Board will guide policy, provide counsel on management and organizational issues and ensure an ongoing process of continuous improvement by reviewing Quarterly Status Reports and offering suggestions for refining, strengthening and improving the project approach as appropriate.

Members of the Advisory Board represent program partners and district leadership from both targeted regions who have a broad range of experience that supports the implementation. These partners work for organizations in the participating states that represent key stakeholders in K-12 education and are fully able to support the schools long beyond the scope of the grant-funded project period. In addition, they will provide valuable context to the educational landscape in each region. Members of the **Advisory Board** include:

Table 2: Members of the Advisory Board
Sam Houston, President and CEO of the North Carolina Science, Mathematics and Technology Center (NC SMT): The NC SMT Center is focused on improving education as a means of providing all students in North Carolina with the knowledge and skills to have successful careers, be good citizens, and advance the economy of the state. Serving as a broker, facilitator, and catalyst for innovation and change in education, the NC SMT Center works closely with school district leadership and classroom teachers to strengthen STEM education while engaging policy makers, business and community leaders in the promotion of STEM.
Tom Peters, Executive Director, South Carolina's Coalition for Mathematics & Science (SCCMS): An alliance of partnering organizations and initiatives working together everywhere that STEM matters to address STEM education challenges in our State through partnerships, advocacy and public engagement.
District leadership representatives from North Carolina and South Carolina: An area of collaboration that will be included in district MOUs will be the participation of district leadership on the Advisory Board. Their participation will ensure that information is adequately disseminated to all levels of school leadership and also give them a voice in the conversation to ensure the alignment of all parties in the work.

Advisory Board meetings will include regular conference calls, which will be guided by an established set of operating procedures that cover strategic management and outline specific roles, responsibilities and expectations of each partner. In addition to Quarterly Status Reports (QSRs), the Project Manager will prepare informal monthly reports that measure progress and point to explicit, measurable gaps or discrepancies in the implementation process to determine a root cause for any barriers to achieving prescribed goals. QSRs (as available) and monthly reports will be shared with the Advisory Board to gauge performance quickly and intuitively. Using this information, project leadership and the Advisory Board can review preliminary performance feedback and use this information to refine, strengthen and improve the approach as appropriate. In addition to the monthly Advisory Board calls, we will also meet annually at the Project Director's meeting to interact with our peers face-to-face, share knowledge and experiences and to discuss challenges, obstacles and successes.

C. Adequacy of the Resources and Quality of the Management Plan (up to 20 points)

(1) The adequacy of the management plan to achieve the objectives of the proposed project on time and within budget, including clearly defined responsibilities, timelines, and milestones for accomplishing the project tasks and (2) The qualifications, including relevant training and experience of key project personnel.

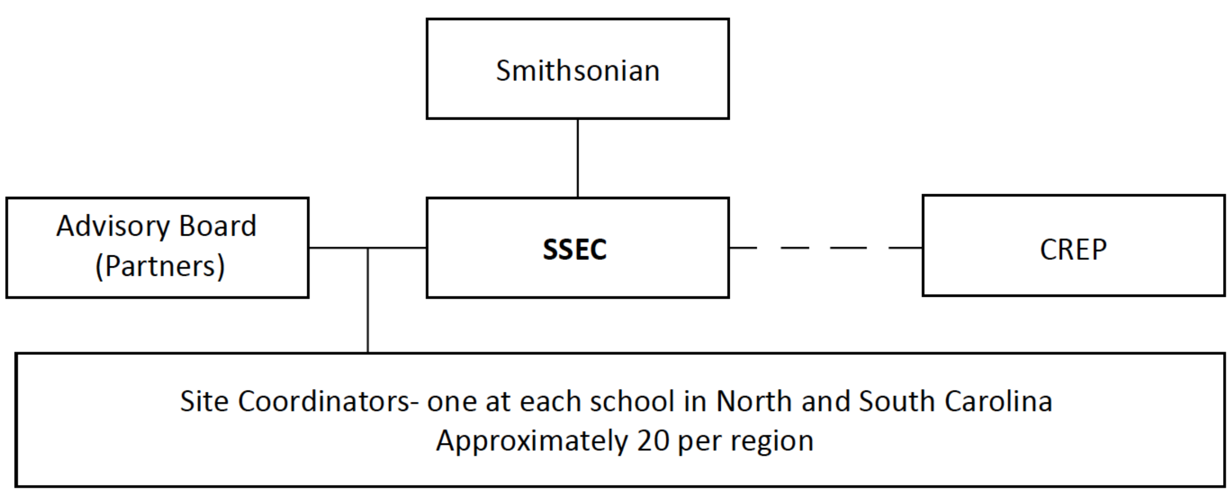
The SSEC will coordinate and manage the "*Smithsonian Science for the Classroom: Improving Student Achievement Across State Borders and State Standards*" project in close cooperation with our external evaluator, the Center for Research in Educational Policy (**CREP)** at the University of Memphis and with our state partners, the NC SMT Center and SCCMS. Site Coordinators based at participating schools will remain in constant contact with evaluators, partners, and SSEC staff. The SSEC, CREP, and the local partners all have demonstrated experience collaborating successfully with districts, schools and teachers.

Amy D'Amico, Division Director of Professional Services, SSEC, will serve as Project Director (Principal Investigator) for the *Smithsonian Science for the Classroom* initiative. Her CV is attached in Appendix B. As the Division Director of Professional Services, a faculty member in Biology at Georgetown University and a former middle school educator who also worked as a teacher leader in Cambridge, MA, Amy will apply the experience gained from these contexts to the implementation of this model in the two states. Amy has demonstrated success in the financial and programmatic management of federal grants (PI on i3 validation grant in 2010 U396B1000097). Carol O'Donnell, Director of the SSEC, will serve as Co-Principal Investigator (Co-PI). Carol's background as an elementary school teacher, a curriculum developer, and a researcher in science education focused on the fidelity of implementation of high-quality curricular materials for teachers will inform the development of innovative professional development workshops and support the overall management of the project (See CV in Appendix B). The

Smithsonian Leadership Team will work in partnership with CREP as the evaluation team (see Figure 1). Reporting to the PI- and Co-PI will be a Program Manager, Katie Gainsback, who will be responsible for organizing the logistics of professional development and serve as the point of contact for the partners and site coordinators (Ms. Gainsback was involved in the i3 project). The **CREP** evaluation team has demonstrated success with large-scale evaluation projects funded through federal grants that they will bring to bear on this evaluation if grant funding is awarded (see Appendix B for CVs of Strahl, Bertz, Zoblotsky, and Gallagher).

Each school implementing the *Smithsonian Science for the Classroom* model will identify Site Coordinators from among existing faculty. Site Coordinators will serve as an on-site mentor for participating educators. In total, approximately 20 Site Coordinators will be identified per state – one at each participating school. Site Coordinators are crucial to the success of this **model**. On the "front lines" of education, these professionals understand what educators in their region face every day because they are literally living it. Site Coordinators serve as organizational contacts for the staff based in Washington, DC, and as instructional mentors/supports for participating teachers in the regions.

Figure 1: Project management organizational chart



Project Roles and Responsibilities: Project responsibilities of the SSEC, CREP and the participating schools are outlined in Table 3 in Appendix I. If awarded the grant, once schools have been matched and randomized, Memorandums of Understanding (MOUs) will be signed by district leadership, school leadership, site coordinators and the SSEC to ensure that clear expectations are understood by all stakeholders.

Financial Management: The Smithsonian Office of Sponsored Projects will assist the SSEC in meeting all financial management and financial reporting aspects of the EIR program. The SSEC will disburse funds among contractors annually. Contractors will be required to abide by all fiscal accountability, transparency and reporting requirements. All disbursed funds will be processed by the SSEC's Finance and Administration Division and approved by the Director of the SSEC. Accounting procedures will follow standard Smithsonian Institution policy guidelines that are aligned to Federal regulations.

Reporting: The Smithsonian Office of Sponsored Projects will provide support and guidance with the reporting process. The SSEC assumes responsibility for maintaining and adhering to the project timeline. Any changes in the project timeline or procedures that result from adjustments in project activities will be decided among the parties cooperating in the program, but the final decision will rest with the SSEC.

Communications: Because the roles of the collaborators are interdependent, we anticipate that all collaborators will work closely throughout the course of the project; however monthly meetings will also be scheduled. After the initial kick-off event, schools will select representatives to act as conduits for communication with the collaborators.

Timeline: The chart below (Table 4) outlines the key activities that will occur in the Fall, Spring and Summer of each year of the grant. Winter is not outlined as work will continue, but no new activities will be implemented during those months.

Table 4: Timeline of activities.

		Intervention	Implementation	Evaluation & Reporting
Year 1 (2019-20)	**Fa**	Recruit schools	School commitment (MOU)	IRB approval Identify observers
	Sp	Develop PD Train-the-trainer for Curriculum PD		Instrument development & observer training Design summary
	Su	Curriculum PD (Module A)		Formative feedback to SSEC
Year 2 (2020-21)	**Fa**	Condensed PD for teachers unable to attend summer PD	Implementation (Module A)	Y2 Data collection Develop student data agreements
	Sp	Develop PD Train-the-trainer for Content PD		Y2 Data collection
	Su	Content PD (Module A)		CREY2 report
Year 3 (2021-22)	**Fa**		Implementation (Module A)	Y3 Data Collection
	Sp	Develop PD Train-the-trainer for Curriculum PD		Y3 Data collection Student data analysis
	Su	Curriculum PD (Module B)		Y3 report
Year 4 (2022-23)	**Fa**	Condensed PD	Implementation (Module A + B)	Y4 Data collection Acquire Y3 student data
	Sp	Develop PD Train-the-trainer for Content PD		Y4 Data collection Student data analysis
	Su	Content PD (Module B)		Y4 report
Year 5 (2023-24)	**Fa**		Implementation (Module A + B)	Acquire Y4 student data Design summary update
	Sp	Train-the-trainer		Student data analysis
	Su	Introductory PD (Module A) Control Schools		Summative report Dissemination

Key: T=Treatment; C=Control; Sp=Spring; Su=Summer; Fa=Fall; Module A=Engineering module; Module B=Science module

(3) The potential for continued support of the project after Federal funding ends, including, as appropriate, the demonstrated commitment of appropriate entities to such

support.

The proposed project will provide much needed resources, both physical and intellectual, to locales that are in dire need of additional support. The resources provided through this grant will lay the foundation to continue the project beyond the lifetime of the grant. Firstly, curricular materials will be provided for the duration of the grant. Upon completion of the grant these curricular materials will remain within the district. The refurbishment cost of consumable items is a comparatively small amount per pupil. Secondly, over the term of the grant local leadership capacity will be developed to ensure that the work can continue beyond the life of the grant. Site coordinators will be given leadership opportunities as partners in the work as well as through providing support to teachers in their schools. Additionally, teachers in treatment schools will be trained as trainers for control schools, deepening the local trainer pool. Finally, the local partners from NC SMT and SCMMS are committed to providing support to schools and districts in their states and will both continue the work as well as grow it state-wide.

D. Quality of Project Evaluation (up to 20 points)

The Center for Research in Educational Policy (CREP) at the University of Memphis (biographies of key researchers Appendix B) will serve as independent third-party evaluator for the project. CREP's previous partnerships with SSEC include evaluation of a five-year Investing in Innovation (i3) Validation study of the SSEC's Leadership and Assistance for Science Education Reform (LASER) Model. This intervention included analyses of student outcomes from an elementary and a middle school cohort, both of which met What Works Clearinghouse (WWC) standards without reservations.

(1) The extent to which the methods of evaluation will, if well implemented, produce evidence about the project's effectiveness that would meet the WWC standards with or

without reservations.

CREP's proposed evaluation is a mixed-methods randomized controlled trial (RCT) involving approximately 52 schools, 300 teachers, and 2,600 students annually in North Carolina (NC) and South Carolina (SC). Within each state, schools recruited to the project (26 per state) will be matched using publicly available state report card data on factors such as grade levels taught, prior student performance on tests of science learning and student demographics (e.g., socioeconomic status) to increase the likelihood that baseline equivalence will be attained. Each school in a matched pair will be randomly assigned to either the treatment or control condition. During the study, CREP will track academic outcomes of a cohort of students (the "study cohort") who are in 2nd grade during Assessment Year (AY) 2019-20, and no late joiners will be included in impact analyses. To provide a standardized measure of student achievement across both states, CREP will work with treatment and control schools to administer a valid and reliable standardized test at the end of the study cohort's baseline (2nd grade) and final (5th grade) project years, such as the Abbreviated Battery of the Stanford Achievement Test Series, Tenth Edition® (SAT-10; Pearson Education, 2018). The confirmatory impact analyses will be the effects of program implementation on student achievement in treatment schools vs. control schools in one domain, Student Achievement, with three outcomes – science, math, and reading – for 1) the overall sample, and 2) in NC vs. SC. Effects within high-needs student subgroups (females, IEP students, eligible for free/reduced lunch).Available standardized state test scores at the end of 3rd and 4th grade will serve as exploratory outcome measures (Table 5).

Table 5: Achievement outcomes for the study cohort.

State	**Grade 2 (Baseline)**	**Grade 3 (Exploratory)**	**Grade 4 (Exploratory)**	**Grade 5 (Confirmatory)**

NC	SAT-10 (all domains)	End-of-Grade (reading & math)	End-of-Grade (reading & math)	SAT-10 (all domains)
SC		SC-READY (reading & math)	SC-READY (reading & math) SC-PASS (science)	

The statistical model (HLM) will account for the nested nature of the data (i.e., students within schools), comparing the post-test controlling for pre-test measures, and an effect size (Hedges' g) will be calculated to determine the magnitude of the impacts. The actual statistical analysis conducted will be dependent on the properties of the data collected. If baseline equivalence is met (based on $g \leq 0.25$), this study design will produce evidence with the potential to meet WWC standards without reservations if sample attrition is sufficiently low, and with the potential to meet WWC standards with reservations if sample attrition is high (What Works Clearinghouse, 2017). Results from student data analyses will be used to address Evaluation Questions 1 and 2 (Table 6).

(2) The extent to which the evaluation will provide guidance about effective strategies suitable for replication or testing in other settings, and (3) the extent to which the methods of evaluation will provide valid and reliable performance data on relevant outcomes.

In addition to assessing student outcomes for the study cohort using a valid and reliable test, CREP will collect data from teachers and classrooms during Project Years (Y) 2 – 4 using four instruments. Results will be used to provide formative feedback to SSEC and to evaluate the suitability and effectiveness of the intervention in two settings with different underlying science standards.

Teachers will complete the Professional Development (PD) evaluation survey after summer PD during Y1 - Y3. This anonymous survey estimates teacher perceptions of the degree to which the PD met their needs and addressed the SSEC's professional development goals, with responses aggregated by state. Results will provide formative feedback for the SSEC and address

Evaluation Question 3 (Table 6).

Teachers will complete an anonymous online SSftC Module Log each time they finish using a *Smithsonian Science for the Classroom* (SSftC) module in their classroom during an academic year (Y2 $n \leq 150$; Y3 $n \leq 150$; Y4 $n \leq 300$). Module Logs give teachers an opportunity to provide feedback on module implementation, perceived alignment with state standards, reception by students, and materials use. Results will be aggregated by state and used to answer Evaluation Questions 4 and 5 (Table 6).

Two rubrics, the Student Observation Measure (SOM) and the Rubric for Inquiry-Based Assessment (RIBA), will be used by trained site researchers to observe science classes during Y2 – 4 in a subset of 14 treatment and 14 control schools (7 of each per state). The SOM is CREP's validated and reliable tool for summarizing practices employed by teachers and behaviors exhibited by students during a lesson (Ross, Smith, & Alberg, 1998) via a 5-point rubric. The RIBA was developed to observe the frequency of ten inquiry-based science activities using a SOM-like structure and frequency scale. To ensure data reliability and increase the extent to which the methods of evaluation will provide valid and reliable performance data, observers participate in an eight-hour annual training course, practice exercises to ensure that the data each site researcher collects is comparable, and monthly conference calls. Observation results provide information about what is truly happening in treatment vs. control classrooms and will be used to answer Evaluation Question 4 (Table 6).

Finally, during Y4 summer PD, CREP will conduct voluntary Teacher Focus Groups with a subset of participants in both North and South Carolina. These focus groups will give teachers – the stakeholders who interact most directly with students – an opportunity to provide detailed feedback on the intervention, and will address Evaluation Question 5 (Table 6).

(4) The extent to which the evaluation plan clearly articulates the key project components, mediators, and outcomes, as well as a measurable threshold for acceptable implementation.

Evaluation questions are presented in Table 6, along with the key project components, mediators, expected outcomes, and target thresholds for acceptable implementation (where applicable) associated with each question. An abbreviated timeline for program evaluation, as it aligns with implementation activities, is presented in Table 7 that can be found in Appendix I.

Table 6: Evaluation questions, data sources, and analyses.

Evaluation Question	**Data source(s)**	**Analyses**
1. Does the intervention improve student achievement, particularly achievement of high needs students, in science, math, and reading to a statistically significant and/or educationally meaningful extent, relative to controls?	• 2^{nd} and 5^{th} grade SAT-10 scores (science, math, reading) • 3rd – 4th grade state test scores (math, reading) (treatment + control schools)	Confirmatory: 5^{th} grade study cohort test scores within treatment vs. control schools Exploratory: 3^{rd} and 4^{th} grade study cohort state test score comparison for students / subgroups within treatment vs. control schools; 5^{th} grade study cohort test score comparison for student subgroups of interest
If curriculum and PD support are effective, then high-needs student subgroups in the study cohort who receive three years of the intervention will show improved academic outcomes in science, reading, and/or math, relative to high-needs students in schools who conduct business-as-usual.		
2. Is adoption of NGSS or NGSS-like standards at the state level associated with a difference in the effect of the intervention on student outcomes?	• 2^{nd} and 5^{th} grade SAT-10 scores (science, math, reading) • 3rd – 4th grade state test scores (math, reading) (treatment + control schools)	Confirmatory: 5^{th} grade study cohort test score comparison within treatment vs. control schools in NC vs. SC Exploratory: 3^{rd} and 4^{th} grade study cohort state test scores for students / subgroups within treatment vs. control schools in NC vs. SC; 5^{th} grade study cohort test score comparison for student subgroups of interest in NC vs. SC

A mediator for the effectiveness of curriculum and PD support is the underlying structure of state standards in the implementation site. If implementing NGSS-aligned curriculum and PD in a state without NGSS-like standards (such as North Carolina) is less effective than implementing the intervention in a state with NGSS-like standards (e.g., South Carolina), then the intervention is best replicated / scaled up to other sites with similar state standards. If there is no difference in effectiveness of the intervention between sites, then further research should examine the intervention's applicability across a broad variety of state standards.		
3. To what extent does the PD meet (a) teachers' perceived needs in NC vs. SC, and (b) SSEC's stated goals?	• PD evaluation surveys (treatment teachers)	Quantitative analysis of level of teacher agreement with items on a Likert-type scale following each summer PD, aggregated by state
The underlying state standards may mediate the extent to which the PD meets teachers' perceived needs, or the PD may address core needs of elementary teachers of science regardless of state standards. Differences in responses to Evaluation Question 3(a) provide formative feedback and information about broader applicability of the intervention. For Evaluation Question 3(b), CREP considers successful implementation to be an average of 75% agreement with survey items related to SSEC's stated goals for the PD.		
4. To what extent are teachers who receive the PD implementing key program components with fidelity in the classroom? Does fidelity of implementation vary with the type of underlying state standards (NGSS-like vs. not NGSS-like)?	• SSftC Module Logs (treatment teachers) • Classroom observations (treatment + control)	Quantitative analysis of items reported by teachers in Module Logs, aggregated by state Quantitative analysis of items scored by observers during science lessons, aggregated by state
The underlying state standards may mediate the extent to which teachers implement the SSFTC modules with fidelity, especially if they are choosing to teach only a subset of lessons that they perceive align with their standards. In turn, fidelity of implementation - particularly the extent of module use and focus on inquiry in the classroom – may mediate observed student achievement outcomes.		
5. To what extent do teachers participating in the overall intervention feel it has been effective? What teacher needs still remain? Do teacher impressions of the intervention vary with the type of underlying state standards (NGSS-like vs. not NGSS-like)?	• SSftC Module Logs (treatment teachers) • Teacher focus groups (treatment teachers, Y4)	Quantitative analysis of items reported by teachers in Module Logs, aggregated by state Qualitative analysis of results from teacher focus groups at the end of Project Year 4, aggregated by state
The underlying state standards may mediate the extent to which teachers feel the overall intervention has been effective and addressed their needs. Responses from teachers in North Carolina and South Carolina may vary if standards are a strong mediator in the applicability of the intervention.		