CLOSING INSPIRATION AND ACHIEVEMENT GAPS IN STEM WITH VOLUNTEER-LED APPRENTICESHIPS

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Response to Competitive Preference Priorities

Competitive Preference Priority 7: Innovations That Support College Access and Success

Citizen Schools' STEM apprenticeship model incorporates strategies that are designed to enable students to successfully prepare for, enter, and graduate from college. Specifically, apprenticeships address students' preparedness and expectations related to college by helping students build academic and 21st century college readiness skills and purposefully incorporating discussions led by staff and community volunteers about their own college experiences, the value of a college education in their field or profession, and what it takes to prepare for and succeed in college. Students participate in field trips to workplaces and colleges that highlight the experience of post-secondary education. Apprenticeships help students understand college affordability and the financial aid and college application processes by describing the value of a college education in the context of specific professions and careers and by emphasizing steps that students must take in middle school and in high school in order to successfully apply to and persist in college (such as selecting a challenging, college-preparatory high school and appropriate coursework). Apprenticeships also provide support to students from peers and knowledgeable adults through the mentorship offered by staff and volunteers, and by actively building a positive, achievement-oriented peer culture through team-building activities and collaborative, project-based learning.

Competitive Preference Priority 9: Improving Productivity

Citizen Schools' STEM apprenticeship model is designed to significantly increase efficiency in the use of time and staff while improving educational outcomes. Specifically, STEM apprenticeships expand the learning day by employing informal educators (who are less costly than classroom teachers) to leverage the expertise of volunteers, with the goal of increasing student interest in STEM fields and ultimately the number of students from underrepresented groups who are prepared for advanced education and careers in STEM. In apprenticeships, volunteers and Citizen Schools staff co-teach weekly afternoon sessions at a host school site. Unpaid volunteers provide content expertise and serve as role models for students, while staff provide complementary support in lesson planning, classroom management, and connecting apprenticeship learning to the rest of the school day. Most of Citizen Schools' staff of informal educators are highly qualified, passionate recent college graduates who are available to Citizen Schools and its school and district members at modest cost through participation in the AmeriCorps national service program. Citizen Schools' expanded learning program, of which apprenticeships are a core component, has a strong track record of impact described in Appendices C and D. The cost efficiency of the model compares favorably with several alternatives available to schools. An analysis by Bain & Company completed in 2011 found that Citizen Schools' costs are comparable to or lower than costs incurred by other nonprofits, traditional schools, and charter schools that have tried to expand the learning day (particularly those adopting teacher-led extended days). The analysis found that Citizen Schools' direct costs are comparable to those of other community-based expanded learning partners, but its services are of higher quality.

Response to Selection Criteria

How can we advance excellence and equity in STEM education? One critical piece of the solution lies in mobilizing the talents of scientists, engineers, and mathematicians to meet this challenge. There are fewer than 250,000 math and science teachers in the United States (U.S. Department of Education, 2008). The population of working scientists and engineers is twenty times larger – five and a half million people with content expertise and authentic knowledge of STEM career pathways, but little connection to low-income children who need exactly what they have to offer (National Science Board, 2010b). What if we could change this equation?

Citizen Schools' unique apprenticeship model brings volunteer experts into high-need schools, where they are supported by trained staff as they share what they know and love with students. In early pilots, students who participated in STEM apprenticeships reported interest in STEM at more than twice national rates, suggesting high potential to help schools close STEM inspiration and achievement gaps. Citizen Schools, in partnership with Boston Public Schools (MA), Chicago Public Schools (IL), Houston Independent School District (TX), the New York City Department of Education (NY), Oakland Unified School District (CA), and Ravenswood City School District (CA), proposes an i3 Development project under Absolute Priority 2 to recruit, train, and support thousands of volunteers to lead STEM apprenticeships. Supported by a $3 million i3 investment, this 3.5-year project will test a promising innovation with the potential to increase the number of students from underrepresented groups who are prepared for advanced education and careers in STEM.

A. Project Design

The proposed project is designed to evaluate and develop the STEM apprenticeship model, taking it from a promising approach to an established program with the evidence and resources to support wider implementation and further testing.

Project Partners

Founded in 1995, Citizen Schools is a nonprofit organization that partners with high-need schools to close achievement gaps by expanding the learning day. Citizen Schools' optional afterschool and full-grade expanded learning programs are based at host schools and incorporate volunteer-led apprenticeships, academic support, and college and career programming in order to prepare students for success in high school, college, and career. Citizen Schools works with schools that serve predominantly low-income (90% nationally), racial or ethnic minority (94% nationally), and academically struggling students. In 2012-13, Citizen Schools' programs will enroll more than 5,000 students at 31 schools in eight states. Through local and national partnerships with organizations such as Google, Cisco, Cognizant, Rutgers University, and the New York Academy of Sciences, Citizen Schools recruits 3,500 or more volunteers annually.

Joining with Citizen Schools in this proposal are six Local Education Agencies: Boston Public Schools (MA), Chicago Public Schools (IL), Houston Independent School District (TX), the New York City Department of Education (NY), Oakland Unified School District (CA), and Ravenswood City School District (CA). Each of the named districts currently hosts Citizen Schools programs and serves a high-need population. (To illustrate, the percentage of students eligible for free or reduced price lunch in these districts ranges from 70% to 89%, and at least 85% of the student population in each district is from a racial/ethnic minority background.)

Overview of the Development Project

Citizen Schools and the applicant LEAs have partnered to identify 17 school sites at which the STEM apprenticeship model will be implemented in the 2012-13 academic year as part of an extended school day (see Appendix J). Implementation data from this pilot year will be used as the basis for adjustments to program design, training, curriculum, and support during the following summer. The revised model incorporating information from the pilot will be implemented in subsequent years in both the Cohort 1 schools and several additional schools each year, for a final sample of 23 schools with varying terms of implementation. Impacts will be estimated on the full sample of Cohorts 1-3 in the final year of the grant (2014-2015) and implementation data from each year will allow for measuring fidelity of implementation of the intervention across schools and cohorts.

Figure 1: Project Design

	Cohort 1	Cohort 2	Cohort 3	Cohort 4
Start of Implementation	Spring 2013 (pilot)	Fall 2013	Fall 2014	Fall 2015
Schools in Cohort	17	2	2	2
Max. Years of Implementation	3	2 ½	1½	½*
Evaluation Focus	Pilot (Implementation)	Impact, Implementation	Impact, Implementation	Not included in evaluation

* The project term will continue until June 30, 2016, with the spring semester reserved for analysis, reporting, and dissemination.

Project Goals and Strategies

The proposed project has the following objectives:

- **Implement at least 1,500 volunteer-led, hands-on, semester-long STEM apprenticeships**, providing more than 20,000 apprenticeship experiences for high-need students in grades 6-8
- **Examine implementation and impact on student outcomes**, both short-term (STEM awareness, engagement, enthusiasm) and mid-term (academic skills, 21st century skills,

increased likelihood of pursuing advanced education and careers in STEM), through an independent evaluation

- **Develop resources and share learning** to inform the field and support future implementation by the project partners and others

Implement Volunteer-Led STEM Apprenticeships for the Middle Grades

In a Citizen Schools apprenticeship, a volunteer expert called a Citizen Teacher (or a team of Citizen Teachers) works with 12-15 students one afternoon a week for ten weeks to explore a new field and create a high-quality product or presentation to share at a community event known as a WOW!. Most apprenticeships take place at students' schools, although some are held at volunteers' workplaces. Students select two apprenticeships each semester, each meeting for 90 minutes weekly. Nearly half of Citizen Schools' apprenticeships are in STEM fields; Citizen Schools recruits, trains, and supports volunteers to lead apprenticeships on topics that range from solar car engineering to stock market investing to electronic textiles. For example, in *It IS Rocket Science*, students learn fundamental principles of physics. For their final project, they simulate the collision of a comet with a space station, receiving coordinates through a live NASA video feed and applying formulas to determine which of three stations is safest for a team of astronauts who can maneuver only by jet pack. In *Scalable Game Design*, students create a simple but complete version of the game Frogger while learning key elements of computational thinking, including basic object interaction, stacks, and algorithms. At the end of the apprenticeship, students demonstrate their Frogger programs for their families, school staff, and community members and offer attendees a turn to play.

Since 1995, Citizen Schools has refined the apprenticeship model, combining the content expertise of community volunteers with a robust school partnership infrastructure and significant staff support. Key feature of this approach include:

Direct access to experts: In a recent survey, a majority of teenagers reported that they may be discouraged from pursuing STEM careers because they do not know anyone who works in these fields and they do not understand what people in these fields do (Lemelson, 2010). While children from higher-income families may have access to networks that include many STEM professionals, and to engaging STEM experiences offered in clubs or camps, many children from low-income backgrounds lack these vital connections, placing them at a profound disadvantage in accessing an entire sector of rewarding and high-growth careers. The apprenticeship model connects students with Citizen Teachers who have authentic content expertise, allowing volunteers to share what they are most passionate about and exposing students to STEM professionals in a variety of fields. "It's amazing how much the kids are more receptive to the topic when they're getting it from someone that they can relate to, or they're getting it from someone who's really enthusiastic," says MacCalvin Romain, an EMC employee and former Citizen Schools participant who recently returned to the middle school he had attended in Boston to teach a computer building apprenticeship like the one that had inspired him. Citizen Teachers can adapt curriculum selected from Citizen Schools' growing library or develop a new apprenticeship in partnership with staff. In 2011-12, STEM apprenticeships included Time to Invent Club (led by volunteers from Google), My Money My Life (led by volunteers from the New Mexico State Treasurer's Office), Crime Scene Investigators (led by volunteers from the University of Massachusetts), Wearable LEDs (led by volunteers from Cognizant) and Generation Technology (led by volunteers from Duke Energy).

Training and support infrastructure for volunteers: Although they are knowledgeable about their apprenticeship topic, the community volunteers who lead apprenticeships may not be experienced in planning lessons or managing classrooms. Thus, volunteers participate in approximately five hours of formal training led by Citizen Schools staff that introduces them to the characteristics of a high-quality apprenticeship, prepares them to "pitch" their apprenticeship to students, and helps them develop their unit guide and WOW! presentation (see Appendix J). Perhaps more importantly, Citizen Schools provides ongoing support. Each apprenticeship is co-taught by a Citizen Schools staff member called a Team Leader, who is present in every session and assists with lesson planning, classroom management, and connecting apprenticeships with students' experiences in school and in other elements of the Citizen Schools program. Team Leaders, many of whom are participants in the AmeriCorps service program, lead all elements of Citizen Schools' program and are based at the school site, where they communicate regularly with students' classroom teachers. Team Leaders receive a week of intensive training each July, followed by additional training with their state and campus teams, and are formally observed six times annually by their managing Campus Director. In addition to their co-teachers, volunteers have access to the campus Citizen Teacher Lead, a staff member who spends his or her mornings on volunteer support. Regular observation using Citizen Schools' Apprenticeship Quality Rubric (Appendix J) ensures that apprenticeships are high-quality and helping students to connect their learning to future education and career opportunities. In spring 2012, 93% of volunteers reported a good, very good, or excellent level of satisfaction with their experience, 91% reported that they had enough timely feedback and guidance from their assigned Team Leader, and 96% reported that they would recommend serving as a Citizen Teacher to friends or colleagues.

Student choice: At the beginning of each semester, volunteers pitch their apprenticeship topics to students and the school community at an Apprenticeship Fair. Students then select two apprenticeships each semester from among those offered at their school, advocating to participate in the most popular courses. Apprenticeships are designed to incorporate relevant, hands-on projects; with topics ranging from aeronautics to the science of soccer, students can select a subject that interests them, increasing their motivation to participate and learn.

Career and college readiness goals: Apprenticeships build skills and awareness that will contribute to students' college and career readiness. Each STEM apprenticeship includes math or science content that brings to life material that students learn in their school-day classes. In addition, each apprenticeship targets two 21st century skills related to interpersonal interaction, informational analysis, or critical thinking (see Appendix J). Every apprenticeship is also expected to address relevant career paths and to build students' understanding of the link between current academic effort and future success through workplace visits, career panels, or volunteers sharing their own experiences,. The degree to which an apprenticeship successfully builds 21st century skills and college and career awareness is formally rated twice each semester (see Appendix J). After participating in STEM apprenticeships in 2011-12, 80% of students expressed interested in STEM fields and careers, more than double the national average of 33% for 8th grade students (Business-Higher Education Forum, 2010).

Experiences of mastery, shared with the community: At the end of each apprenticeship, students share what they've learned with the community at an event called a WOW!. For example, in an urban planning apprenticeship, students might present their architectural model for a new subway station, describing the features they included and the process they used to make decisions about the design. In a forensic accounting apprenticeship, students might explain

to guests how they solved a fraud case by identifying duplicate Social Security numbers in company records. At WOW! events, students become the experts, showing off their new skills to their families and teachers. Students' experience of success in apprenticeships is powerful for them, and for the adults around them. "I think the WOW! showcases were a great asset," one Citizen Schools parent shared on a spring 2012 survey. "[My children] had the ability to work hard on a project, gain real life experience and show it off while using communication skills to explain the basics. I loved seeing them so proud of themselves."

Up to 16,000 students will participate in STEM apprenticeships during the project period.

Figure 2: Project Scale

	Spring 2013	2013-14	2014-15	Fall 2015	TOTAL
Schools	17	19	21	23	
Students*	3,500	3,800	4,200	4,500	16,000
STEM Apprenticeships	185	455	560	300	1,500
Apprenticeship Experiences**	2,775	6,825	8,400	4,500	22,500

* Reflects total enrollment in the Citizen Schools program. Individual students participate in up to four STEM apprenticeships each year and may participate for multiple years.
** Assumes 15 students per apprenticeship, the typical size of a Citizen Schools apprenticeship.

As described in more detail below (see Anticipated Positive Impact), current research supports the potential for apprenticeships with these key features to increase student interest in STEM and ultimately to increase the number of students from underrepresented groups who are prepared for advanced education and careers in STEM.

Examine Implementation and Impact

Independent evaluation providing formative implementation data for model design and improvement in the pilot year, ongoing fidelity of implementation data in subsequent years, and impact data on student outcomes in the final year is core to the proposed project. A detailed evaluation plan in provided in the Project Evaluation section of the narrative below.

Develop Resources and Share Learning

In addition to implementation and evaluation, the project partners intend to use the proposed grant to improve the STEM apprenticeship model and to develop resources that will support implementation by the partners and others during and beyond the grant period. The partners will develop a suite of implementation tools; share those tools to support schools, community-based organizations, corporations, and volunteers in scaling the apprenticeship model; and ensure that learning from the project is disseminated. These activities, which would be concentrated in the second half of the grant period, include: developing a library of 30+ high-quality, open-source STEM apprenticeship curricula based on successful Citizen Schools apprenticeships and materials shared by other content experts and STEM educators; creating model staff and volunteer training modules, including trainer guides; piloting online platforms for dissemination of curriculum and training beyond Citizen Schools' network; sharing learning, including evaluation findings and best practices, with the practitioner community through publications and presentations; and publishing site profiles documenting promising practices in expanded day STEM education and volunteer involvement. Qualified Citizen Schools staff will lead these activities, building on and accelerating ongoing internal efforts such as an online curriculum library and an annual summit of Citizen Schools' network.

Project Cost

With a total project cost of $5.3 million, requested i3 support of $3 million would leverage both a 44% private match and the untapped energy of thousands of expert, enthusiastic STEM volunteers. At a cost of approximately $3,500 per apprenticeship ($235 per participating student per apprenticeship), it would provide more than 20,000 apprenticeship experiences for up to 16,000 high-need students who currently have limited opportunities for authentic STEM

learning; generate and disseminate knowledge about the impact of those experiences on students' interest and skills; and underwrite the development of resources to facilitate adoption of a powerful apprenticeship model by schools, volunteers, corporations, and nonprofits.

The costs of the proposed project are sufficient to achieve the project goals and reasonable relative to the project's significant potential impact on student interest and pursuit of STEM careers. As described in the attached budget justification, the project's expenses are primarily in the form of personnel (Team Leaders who directly support apprenticeships, Campus Directors who oversee apprenticeships at each site and manage Team Leaders, and staff who recruit volunteers and develop curriculum and training). These staff provide the infrastructure and support that are necessary to ensure high-quality implementation at significant scale and are sourced from pools of qualified personnel who can fill roles at reasonable cost. (Most Team Leaders members of the AmeriCorps national service corps.) Start-up investments, including establishing school partnerships, developing curriculum and training, and evaluating the program, will enable the apprenticeship model to be appropriately implemented and tested.

At large scale, costs are estimated assuming that students participate in two apprenticeships each semester in groups of 15, with each apprenticeship led by a volunteer and supported by a national service fellow. In the scale scenario, apprenticeships are modeled as a stand-alone intervention rather than one component of an integrated model, allowing each fellow to support four apprenticeships each semester. Curriculum and training are assumed to be available at zero or nominal cost, with one coordinator at each school site (school size: 300) overseeing fellows and leading volunteer recruitment. With these assumptions, costs are estimated at $1,013 per student annually, so the estimated cost of reaching 100,000 students is

$101 million, the estimated cost of reaching 250,000 students is $253 million, and the estimated cost of reaching 500,000 students is $507 million.

Potential and Planning for Incorporation into Ongoing Work

The proposed project builds on an existing infrastructure of collaboration between Citizen Schools and its partner districts and is intended to be incorporated into their ongoing work. Citizen Schools has operated after-school and expanded learning programs that include an apprenticeship component since 1995 and plans to continue operating such programs, with an emphasis on STEM, after the conclusion of the proposed grant period. Citizen Schools and its partner districts will conduct joint planning for future programs during the project period, and Citizen Schools will also develop resources to facilitate apprenticeship implementation both within and beyond the Citizen Schools network after the conclusion of the project period.

B. Significance of the Project

An Exceptional Approach

Continued challenges in developing a diverse and prepared STEM workforce, along with the structural barriers to powerful STEM education commonly faced by schools serving high-need and traditionally underrepresented students, have been well-documented (Carnegie Corporation, 2009; National Academy of Sciences, 2005, 2010; Committee on Underrepresented Groups, 2010; McMurrer, 2008; National Science Board, 2010; PCAST, 2010). While Citizen Schools and its partner districts are not alone in identifying the nation's STEM education challenge, they are uniquely positioned to offer a promising solution.

The critical innovation of the apprenticeship model is that it directly addresses the barriers that prevent high-need public school students from accessing the STEM experts in their communities. Through its district partnerships, Citizen Schools works with low-income students

from where most of them are – at traditional public schools – and connects thousands of students attending struggling schools in low-income communities with thousands of volunteer Citizen Teachers annually. Schools, which often lack the capacity to recruit, train, and support volunteers, can use the well-defined apprenticeship model as an umbrella for community engagement; as the Assistant Principal of Elmhurst Community Preparatory Academy in Oakland, California, has said, "Citizen Schools being on our campus allows us to work with folks who want to work with our kids."

With its combination of flexibility and support, the apprenticeship model offers a volunteer experience that is both sustainable and meaningful, demonstrating the potential to mobilize the millions of STEM professionals who are not full-time teachers to meet the STEM education challenge. While students and schools benefit from the presence of STEM experts, apprenticeship volunteers benefit from a structured, focused opportunity to share their passion for STEM and to witness impact on students. "It was great to see nine kids have perhaps their first-ever experience with telling technology what to do, rather than just listening to what technology tells them," wrote one STEM volunteer in fall 2011. "It was great to be a part of it." Citizen Schools' unique approach to engaging part-time, long-term STEM volunteers in teaching apprenticeships was recognized with the 2011 People's Choice Award in the *Partnering for Excellence: Innovations in STEM Education* competition hosted by Ashoka Changemakers, and Citizen Schools' STEM initiatives were recently featured on the White House blog (Kalil, 2012).

STEM apprenticeships are also designed to increase STEM interest during the middle grades, a pivot point in the educational trajectories of at-risk students. Research has demonstrated the importance of the middle grades in establishing students' educational and career outcomes (Balfanz, Herzog, and MacIver, 2007; Bedsworth, Colby, and Doctor, 2006)

and has also indicated that interest in STEM careers by 8th grade is a significant predictor of whether a student will graduate from college with a STEM degree (Tai et al., 2006). In the STEM fields in particular, relevance and role models are crucial to lifting students' aspirations and performance and opening the door to advanced coursework and extracurricular opportunities. "Now that I know what a lab looks like, I can actually make a mental picture of how it would look if I worked inside a laboratory," said one student who visited Rockefeller University as part of a brain science apprenticeship. "One thing we realized was how important exposure is," said Citizen Schools Campus Director Cassandra Jones in a profile of one of Citizen Schools' first STEM-focused sites. "These kids have not had the opportunity before to see if that spark of interest [in STEM] is there" (National Center on Time & Learning, 2011).

Anticipated Positive Impact

As shown in the logic model (Figure 3, p. 29), the project is expected to significantly increase STEM interest and aspirations, achievement, and college readiness, ultimately increasing the number of individuals from traditionally underrepresented groups who are prepared for education and careers in STEM. The project partners anticipate these positive impacts based on evidence from studies of Citizen Schools' afterschool and expanded learning programs, early evidence from STEM apprenticeships, and research from the field. This evidence is described in more detail in Appendix D. Key findings include:

- Citizen Schools' programs, which include apprenticeships in various fields, have produced significant and substantial impact on student attendance, grades, state test scores, and graduation rates (Arcaira, Vile, and Reisner, 2010).
- Activities that incorporate hands-on projects, relevant topics, collaboration, and student input are likely to increase students' engagement in school (Marks, 2000). In general,

"learners of all ages are more motivated when they can see the usefulness of what they are learning and when they can use that information to do something that has an impact on others—especially their local community" (Bransford, Brown, and Cocking, 2000: 61). These features are shown specifically to improve students' attitudes toward science and STEM (Myers and Fouts, 1992, and Piburn and Baker, 1993, cited in Maltese and Tai, 2011) and science learning (Rivet and Krajcik, 2007). Citizen Schools' STEM apprenticeships, which incorporate these features, are indeed associated with increased STEM interest in early data. After participating in STEM apprenticeships in 2011-12, 80% of students expressed interested in STEM fields and careers, more than double the 33% national average for 8th grade students (Business-Higher Education Forum, 2010).

- Student interest in a STEM career in 8th grade is associated with increased likelihood of earning a STEM college degree (Tai et al., 2006; Maltese and Tai, 2011). In general, interest is at least as important as achievement or course enrollment in predicting advanced education and careers in STEM fields (Maltese and Tai, 2011), perhaps in part because "interest is an important filter for selecting and focusing on relevant information in a complex environment. People pay attention to the things that interest them; hence, interest can drive what is learned" (Fenichel and Schweingruber, 2010: 82).

Contributions to the Field

This project offers the potential to advance both practice and theory related to increasing the number of students from underrepresented groups who are prepared for advanced education and careers in STEM. If successful in meeting the project objectives, it will produce:

- A well-developed program model that is ready to be replicated and scaled.

- A powerful example of how to engage and support STEM professionals in high-need public schools through meaningful, sustainable volunteer experiences.
- A suite of curriculum, trainings, case studies, and other tools that will support practice.
- Evidence of the impact of STEM apprenticeships on students' interest in and preparation for advanced education and careers, advancing the program evaluation literature.
- Data on apprenticeship characteristics and implementation features that are associated with positive student outcomes, contributing to our understanding of effective practice.

Most broadly, the proposed project will respond to the profound need for an imaginative approach to STEM education that utilizes all of the resources available in our communities. It will offer a concrete, proven, and replicable model of how to employ the talents of current STEM professionals to close inspiration and achievement gaps for millions of children, strengthening and diversifying the STEM pipeline.

C. Management Plan and Personnel

Management Plan

Together, the project partners have the capacity to achieve the project goals on time and on budget and have developed a clear division of responsibilities and timeline for managing the project, with key high-level activities outlined in Figure 4 (p. 30). Citizen Schools' expertise in volunteer mobilization and expanded day instruction, district and school relationships, and talent recruitment and support systems uniquely qualify it to lead the proposed project in achieving its objectives. The project's LEA partners are committed to providing active support for the project by facilitating school partnerships, data access, and other key infrastructure.

Experience managing large and complex projects: Since its founding in 1995, lead project partner Citizen Schools has replicated its programs successfully and scaled its

innovations in diverse settings. From 2006 to 2009, Citizen Schools grew its enrollment by an average of 44% per year and maintained a consistent level of student gains. An implementation study conducted by Policy Studies Associates found that Citizen Schools consistently replicated its core program elements across sites with fidelity (Sinclair et al., 61). As the lead i3 partner, it can move purposefully to implement a large-scale project with numerous elements and partners.

Volunteer recruitment, training, and support systems: The ability to recruit, train, and support STEM volunteers at sufficient scale will be critical to the success of the project, and Citizen Schools is positioned to take on this responsibility. In 2011-12, Citizen Schools staff successfully executed volunteer recruitment, training, and ongoing support for nearly 4,000 volunteers, nearly half in STEM fields. Citizen Schools has developed robust pipelines of volunteers through partnerships with corporations, universities, and professional and community organizations. Dozens of leading companies, including Google, Cognizant, Fidelity, and Bank of America have deployed employees as volunteers and worked with Citizen Schools to develop apprenticeships. Citizen Schools has already committed to recruiting large numbers of volunteers in STEM fields through its involvement with 100Kin10 and the Clinton Global Initiative.

Sufficient financial resources: Citizen Schools and its partner LEAs will secure sufficient financial resources to implement the project fully and achieve its objectives. As detailed in the attached budget narrative, support for the project will be provided by a combination of i3 grant funds and matching funds that substantially exceed the 15% match requirement.

As the lead applicant, Citizen Schools accepts primary responsibility for securing matching funds from businesses, individual donors, and major foundations. Citizen Schools has a track record of securing private sector funding for major initiatives, including two recent growth capital campaigns to support national expansion (a $31 million campaign for 2007-12 and an

$18.6 million campaign for 2012-14). Portions of these funds may be allocated toward the proposed STEM apprenticeship project. Citizen Schools has also secured major grants for its STEM work, including a $1 million grant from the National Science Foundation, a $3.25 million grant from Google, a $1.5 million grant from Cognizant Technology Solutions, and a $500,000 grant from Carnegie Corporation of New York.

Citizen Schools has a track record of effective financial management and grants administration. It has received grants from the U.S. Department of Education, the National Science Foundation, and the Corporation for National and Community Service, and has met reporting and matching funds requirements for each agency. Citizen Schools has always had a clean audit report and has received high praise for its programmatic and financial management from its public sector funding partners.

Track record of effective collaboration: Citizen Schools currently operates programs that include an apprenticeship component in each of the districts participating in the proposed STEM apprenticeships project. (Programs in Chicago are launching for the first time in fall 2012, and Citizen Schools has operated in the other districts for a minimum of one year [Ravenswood City School District] and a maximum of 17 years [Boston].) These school and district partnerships have improved student outcomes (as described in Appendices C and D), and Citizen Schools has earned a reputation as a trusted, long-term partner. “Citizen Schools has clearly demonstrated its ability to link students with professionals from a wide range of fields to deliver effective learning and career explorations… When Citizen Schools partners effectively with a school, the results are impressive,” writes Dr. Terry Grier, Superintendent of the Houston Independent School District, in a letter of commitment included in Appendix A. Citizen Schools has also worked effectively with independent evaluators, including Policy Studies Associates and Abt Associates.

Qualifications of Project Personnel

The project's lead personnel from Citizen Schools possess substantial experience in recruiting and training volunteers, implementing educational programs for high-need students, working in partnership with other organizations, and implementing complex projects. Resumes for key personnel are included in Appendix F.

Lead personnel from Citizen Schools: **Claudia Alfaro**, Chief External Engagement Officer, joined Citizen Schools in 2007 and previously held positions at Building Excellent Schools and the Council of International Educational Exchange. Claudia oversees Citizen Schools' volunteer recruitment strategy and builds partnerships with key corporate and institutional partners. **Priscilla Cohen**, Chief of Strategic Initiatives, oversees many of Citizen Schools' key STEM initiatives, including a three-year, $1 million grant from the National Science Foundation and Citizen Schools' National Science and Technology Advisory Committee. Priscilla was a founding board member of Citizen Schools and previously held positions at McKinsey & Company and Beth Israel Deaconess Medical Center. **Michael Kubiak**, Director of Research and Evaluation, oversees Citizen Schools' internal data collection and evaluation work and coordinates with external program evaluators. Prior to joining Citizen Schools in 2010, Mike held programmatic, research, and policy positions at the Annenberg Center for School Reform, the Clinton HIV/AIDS Initiative, the U.S. Department of Education, and the University of Michigan School of Education. He has an Ed.M. from the Harvard Graduate School of Education and an MBA from Boston College. **Melissa Rouette**, Chief Program Officer, manages the implementation of Citizen Schools' program elements and related training for staff and volunteers. She is a former corps member (and Teacher of the Year), Program Director, and Director of Program Design for Teach for America and joined Citizen

Schools in 2007. **Eric Schwarz**, CEO, co-founded Citizen Schools in 1995 after experience as a journalist, a Public Service Fellow at the Kennedy School of Government, and a Vice President at City Year. Eric speaks and writes broadly on education, service, and social entrepreneurship, and recently authored a chapter in the bestselling book *Waiting for Superman* and presented to the National Science Foundation and to Presidential award-winning math and science teachers. Citizen Schools' **National Science and Technology Advisory Committee**, **Board of Directors**, and **Evaluation Advisory Board** will advise on project strategy (see board lists in Appendix J).

Lead personnel from partner districts and schools include superintendents, assistant superintendents, principals, expanded learning day coordinators, and others. As noted in the LEA letters of commitment included in Appendix A, partner districts have committed the resources necessary to ensure that the project achieves its objectives.

D. Project Evaluation

Citizen Schools has engaged Abt Associates Inc. to conduct an independent evaluation of the STEM apprenticeship i3 project that will inform program development and assess impact on students and schools. The evaluation will provide high-quality implementation data and performance feedback; generate sufficient information about the key elements of the project to facilitate further development, replication, and testing; and be supported by qualified personnel and sufficient resources (including $350,000 for independent evaluation in the project budget).

Methods Appropriate to Size and Scale of Project

The evaluation will include both an Implementation Study and an Impact Study. The Implementation Study will include a pilot study during the first six months of the grant, and ongoing formative evaluation during the 2013-2014 and 2014-2015 school years. The Impact Study will use a quasi-experimental comparative interrupted time series approach to examine

school-level outcomes related to general achievement and STEM outcomes. By examining the performance of schools adopting Citizen Schools' STEM apprenticeship model before and after implementation, estimating the break from prior trends in outcomes, and then comparing those findings to the before and after outcomes for a set of comparison schools, this study will allow for the most rigorous possible estimates of program impact.[1] Both implementation and impact studies are designed to meet i3 criteria and to provide extensive performance feedback and implementation data for model development and refinement as well as precise estimates of the intervention's effects on student outcomes.

The evaluation design is informed by a logic model (see Figure 3, p. 29) that connects key activities of Citizen Schools and its partners with program elements (outputs) as well as with the expected effects of the project on participants (outcomes). Activities will be monitored internally, while the independent evaluation will focus on outputs (critical features of implementation) and outcomes.

Research Questions

The key question for the Implementation Study is: How well do participating sites implement the STEM apprenticeship model? The key questions for the Impact Study are as follows: 1) What are the impacts of implementing the STEM apprenticeship model on students' academic performance on state standardized tests in math and, for available grades, in science? 2) How do observed impacts vary as a function of the amount of time schools have been implementing the STEM apprenticeship model and the number of years students are exposed to

[1] Random assignment of schools to the intervention was considered; however, partnership districts are interested in immediate intervention in candidate schools, there are insufficient numbers of candidate schools in some districts to support school-level random assignment, and some partner districts plan to implement Citizen Schools' program at most or all eligible middle schools.

the STEM apprenticeship model? 3) How is implementation related to outcomes?

Implementation Study

The first phase of the Implementation Study will be the pilot study of the STEM apprenticeship model in the 17 Cohort 1 schools during Spring 2013**.** During this phase, the evaluation will explore how the model is being implemented in schools and provide data to developers for intervention improvements. In addition, this phase will be used to pilot test survey items/instruments, classroom observation measures, and interview protocols (see measures description below) to identify which measures can most feasibly and parsimoniously yield useful information about ongoing implementation with the least burden on participants.

In the second phase – during the 2013-14 and 2014-15 school years – the evaluation will monitor the level of implementation in participating i3 schools. The study team will assess the implementation of the STEM apprenticeship model along such key dimensions as the nature and quality of the STEM-focused apprenticeships, academic focus, and increased amount of time for core academics (and STEM content specifically). Through observations, interviews, and teacher/student surveys, the study will focus on students' participation in STEM instruction and learning. It will examine how the apprenticeships are being implemented and integrated into the students' overall learning experiences, describe the amount of time devoted to STEM topics during the school day and how time for STEM instruction is organized (e.g. in longer segments, with greater frequency, required courses rather than elective courses, etc.), how schools engage STEM professionals in apprenticeships, and how students engage in STEM-focused apprenticeships. Key evaluation activities for the implementation study are summarized below:

- Classroom Observations. The evaluation team will conduct classroom observations designed to measure classroom climate, instructional practices, and student engagement.

Pairs of evaluators will observe science and math classes as well as Citizen Schools' program to gain a clearer understanding about the teaching strategies employed by the various school staff, the relationships between students and between students and teachers, and the level of student engagement and enthusiasm for STEM.

- Interviews with formal and informal educators. Employing both in-person and telephone interviews, the evaluation team will ask school teachers, administrators, and informal staff about the degree of cooperation and collaboration between formal and informal educators, integration and coordination of STEM concepts across the school day, and successes/barriers to implementing the enhanced STEM apprenticeships.
- Student and Teacher Surveys. The evaluation will field (annual) online surveys to teachers and other key middle grades staff (e.g., guidance counselors) in both project and comparison schools. Topics for the surveys include uses of instructional time, availability of and participation in afterschool programming, school-based relationships with community partners, teachers' perceptions of school climate and student engagement, and implementation of the STEM apprenticeship model (for program schools only). Additionally, the study will field annual paper surveys to students in schools that have adopted the STEM apprenticeship model. Student survey topics include interest in school, self-assessment of school performance overall and in STEM courses specifically, and in-school and out-of-school STEM courses and activities.

The study will use modified versions of existing classroom observation protocols (e.g., Reformed Teaching Observation Protocol (RTOP) (Piburn & Sawanda, 2000); Inside the Classroom Observation and Analytic Protocol (Horizon Research, 2000)) to collect information about STEM content, instructional strategies and materials, and classroom culture. Similarly, the

study team will use interviews and surveys that have been used in prior evaluations (e.g., Evaluation of Massachusetts Expanded Learning Time Initiative (Abt Associates, 2012)) and modified versions of existing surveys of student attitudes toward science (e.g., Attitudes Toward Science Inventory: version A (Weinburgh & Steele, 2000); Scientific Attitude Inventory II (Moore & Foy (1997)). In addition, Abt is also developing an ELT implementation index that reflects the core Citizen Schools program elements outlined in the logic model; this index incorporates survey data from both Citizen Schools and comparison schools to assess fidelity of implementation, and to document any significant changes in the model as implemented. [The implementation index can also be employed in impact analyses to establish treatment-control contrast, and allow for models that relate outcomes to implementation variables; see below.].

Impact Study

The study includes staggered cohorts of schools adopting the STEM apprenticeship model over two and a half years (Spring 2013, 2013-2014 and 2014-2015) as well as a matched comparison group of schools not adopting the model, and tests for differences in students' math and science outcomes (based on extant data from districts). To increase statistical power, each Citizen Schools STEM apprenticeship school will be carefully matched with four comparison schools that have similar demographic and achievement profiles, as well as an alternate comparison school. Every effort will be made to identify matched comparison schools located in the same district, though for some schools in small districts this may not be possible. The matching process will incorporate extensive pre-implementation data on student achievement (including five years of pre-intervention achievement data where available), demographics, and other factors that might influence student outcomes. This process is flexible, and can be customized for each school (and district) to incorporate differences in data availability and

characteristics of Citizen Schools STEM apprenticeship schools and their potential matches. Abt will also consult with school and district officials to confirm the suitability of proposed matches.

It is possible that schools in the matched comparison group will adopt reforms with some similarity to the STEM apprenticeship model during the study period, or even that they would choose to adopt the model in future years. Abt will address this concern by eliminating schools identified as likely to adopt the STEM apprenticeship model in the near future (within one or two years) from the pool of matches. The inclusion of four matched comparison schools for each treatment school, an approach Abt has used in similar studies, also means that any matched school adopting the model could be removed from the matched comparison group and replaced by the alternate match (or, if no appropriate alternate is available, the comparison schools could be reduced to three, still providing adequate statistical power). Abt will also apply the implementation index developed for the study to both treatment and comparison schools, providing a detailed measure of treatment-control contrast with respect to critical features of the intervention.

To answer the first research question about student outcomes in math and science, we will fit an analytic model that incorporates (i) school fixed effects that absorb time invariant factors that are specific to each treatment school and its matched comparison schools, (ii) two trend variables capturing changes that occurred in the outcomes of treatment and comparison schools before the initiation of the STEM apprenticeship model, and (iii) dummy variables representing the number of years of STEM apprenticeship model implementation. Demographic controls will also be included in the model. Abt has estimated minimum detectable effect sizes

(MDES) of 0.11 for math achievement outcomes, which are available for all schools.[2] For science outcomes, the MDES will be higher (.14) because only 16 schools are implementing the STEM apprenticeship model in the 8th grade and can be included in the analysis. These MDES estimates are calculated utilizing results from the Abt Massachusetts ELT study, which employs a similar design to the proposed study.[3] To address the second research question, we will conduct analyses for subgroups of schools and students that are created based on the duration of implementation and exposure to the STEM apprenticeship model program, respectively. Similarly, to address the third question, we will conduct separate analyses for subgroups of STEM apprenticeship schools and their matched comparison schools, where subgroups are constructed according to schools' implementation levels (e.g., high and low implementers).

Qualifications of Independent Evaluation Staff

Dr. Beth Gamse, Principal Associate at Abt Associates, is currently leading a statewide study of Expanded Learning Time in Massachusetts and a district-focused study of ELT in New York City. She recently directed two national studies of the Reading First Program for the U.S. Department of Education, one an impact study for the Institute of Education Sciences, and the other an implementation study for the Program and Policy Studies Service.

Dr. Alyssa Rulf Fountain is an Associate at Abt Associates. Dr. Rulf Fountain will be responsible for management of the project evaluation and will take a lead role in data collection and writing. Dr. Rulf Fountain has extensive experience in evaluation of federal and local

[2] This estimate applies to analyses conducted with the full analytic sample of 23 STEM apprenticeship schools and 92 matched comparison schools.

[3] The MDES estimate from the Massachusetts ELT study for academic achievement (7th grade ELA or 8th grade Math test) is 0.17. This estimate is based on 80% statistical power and a two-sided significance test with the critical value of 0.05.

programs as well as expertise in educational testing and measurement, instrument design, data collection, and analysis. Dr. Rulf Fountain is Project Director of Abt's national evaluation of Citizen Schools' Expanded Learning Time initiative and was Project Director for two studies of NASA education programs. Dr. Rulf Fountain has a Ph.D. in Biological Psychology from the University of Massachusetts, Amherst.

Conclusion

Research and experience suggest that the STEM apprenticeship model may offer a promising approach to closing opportunity and achievement gaps in STEM fields. With i3 support, Citizen Schools and its district partners look forward to implementing 1,500 STEM apprenticeships for high-need students, examining their implementation and impact, developing resources, and sharing learning to advance theory and practice.

Figure 3: Logic Model

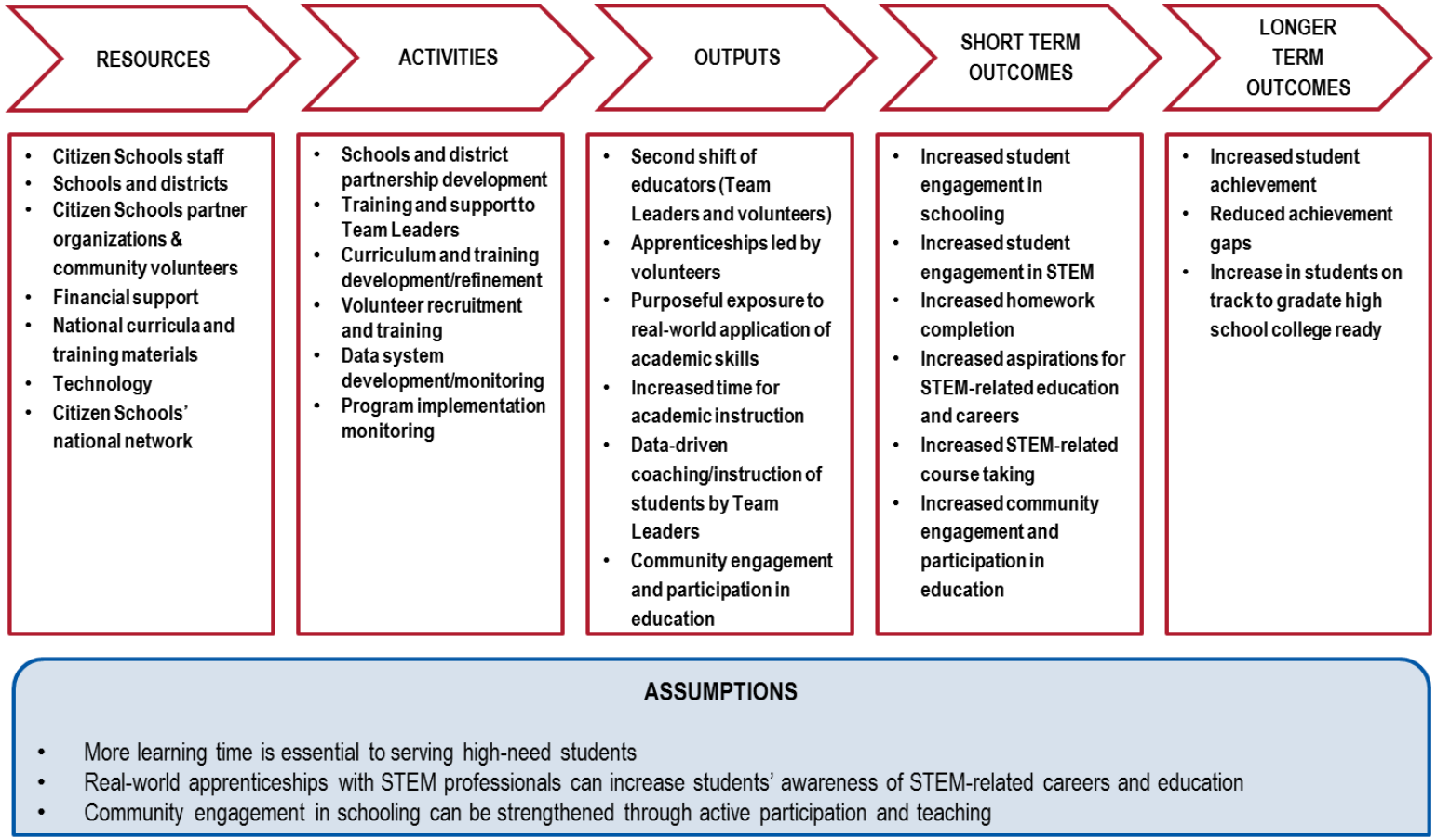

Figure 4: Timeline and Workplan Summary

Objective	Activity	Responsible Personnel	Year 1 2012-13		Year 2 2013-14				Year 3 2014-15				Year 4 2015-16				Deliverables
			Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Implement STEM apprenticeships	Secure program sites	State Executive Directors (Citizen Schools) and district/ school leaders	●	●			●	●			●	●					
	Volunteer recruitment	Claudia Alfaro (CS Chief External Engagement Officer)	●	●	●	●	●	●	●	●	●	●	●				3,000+ volunteers recruited and trained
	Volunteer training	Melissa Rouette (CS Chief Program Officer)	●		●		●		●		●		●				
	Staff training				●				●				●				
	Apprenticeship implementation		●	●	●	●	●	●	●	●	●	●	●	●			1,500 STEM apprenticeships
	Revise training, curriculum, and support			●	●			●	●								
Examine implementation and impact	Pilot instruments and protocols	Beth Gamse and Alyssa Rulf Fountain (Abt Associates) and Mike Kubiak (CS Director of Research and Evaluation)	●	●													Annual implementation reports
	Implementation study		●	●	●	●	●	●	●	●	●	●					
	Impact study				●	●	●	●	●	●	●	●					
	Analysis and reporting												●	●	●	●	Final outcomes report
Develop resources and share learning	Develop STEM apprenticeship curriculum library	Melissa Rouette (CS Chief Program Officer)	●	●	●	●	●	●	●	●	●	●					30 STEM apprenticeship curricula
	Develop model staff and volunteer training modules				●	●	●	●	●	●	●	●	●	●			Staff and volunteer training modules
	Pilot online platforms for disseminating curriculum and training	Priscilla Cohen (CS Chief of Strategic Initiatives)											●	●	●	●	Online curriculum and training portal
	Share learning through publications							●				●				●	Three program profiles
	Share learning through presentations										●	●	●	●	●	●	White paper sharing promising practices