Scientists for Tomorrow - A Self-Sustained Initiative to Promote STEM in Out-of-School Time Frameworks in Under-served Community-Based Organizations: Evaluation and Lessons Learned

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Scientists for Tomorrow: The evaluation and lessons learned from a self-sustained initiative to promote STEAM in out-of-school-time frameworks in underserved, community-based organizations

Abstract

In 2011, the Scientist for Tomorrow (SfT) initiative was created after receiving a grant from the National Science Foundation's Informal Science Education program. The SfT initiative is designed to utilize a science-based curriculum to provide urban youth in Chicago with information and skills related to science, technology, engineering, arts and mathematics (STEAM) careers and foster positive attitudes toward STEAM subjects and related careers. This grant financially sustained SfT and allowed it to serve 15 out-of-school-time organizations for two years. Today, the SfT initiative is in its sixth year, serving more than 40 out-of-school time organizations, 600 middle school student and 150 parents per semester in a self-sustained mode.

The Scientists for Tomorrow initiative is a partnership between postsecondary institutions, out-of-school time organizations and informal-science education providers. The initiative is implemented throughout communities during the academic school year exploring different learning module, such as "Alternative Energies," "Physics of Sound and Mathematics of Music," "People and Plants," "Robotics" and "Astronomy". Before each module starts, the SfT initiative provides more than 15 hours of professional development for all of the instructors involved in the program. Each session includes 10 weekly, 90-minute classes exploring the modules, as well as a Family Science Day field trip, where participating students and their families are invited to one of SfT's partner institutions, including the Museum of Science and Industry, The Field Museum of Natural History and the Peggy Notebaert Nature Museum.

The question the SfT initiative explores is if there are changes in participants' and out-of-school time organization leadership's attitude towards STEAM, as well as a gain in content knowledge. To study this question, participants are given a survey gaging their attitudes and knowledge about STEAM before and after each module. Additionally, all instructors are required to complete Activity Journal Logs after each of their class sessions. These journals allow instructors to reflect on their classes and help to identify where they needed more support from the SfT initiative. Finally, the out-of-school-time organization's director, program coordinators and volunteers are given a survey to evaluate the program as a whole at the end of each module. Four years of external evaluation show that the SfT initiative cultivates a modest gain in content knowledge and an increase in positive attitudes towards STEAM. The findings also show a significant, positive change of attitude from out-of-school-time organizations' leadership toward the introduction of STEAM academic enrichment activities as part of the regular activities in their out-of-school-time programs.

As the Scientists for Tomorrow initiative has grown, some of the lessons learned include 1) the need to have more parental involvement in the SfT initiative's activities to ensure success, 2) the need to provide instructors with flexible professional development opportunities and feedback conversations to ensure the quality of the learning process remains high and the growth of the out-of-school-time organizations' capacity to continue promoting STEAM as an integral part of their out-of-school-time model, and 3) the need to promote the public perception that out-of-school-time learning is as important as formal education in helping academically advance students, especially those in underserved communities.

Introduction

This paper will address the question of whether the implementation of the Scientists for Tomorrow initiative in out-of-school-time organizations promotes the gain of content knowledge and positive changes in participants' and organizational leadership's attitude towards STEAM. In order to analyze if the SfT initiative is having this desired positive impact, it is necessary to clarify two components that structures the framework of the program: what is STEM/STEAM education and what are out-of-school time activities and programs.

For the purpose of this work, STEAM-oriented out-of-school-time programming will be defined as a voluntary and structured framework conducive to learning STEAM contents outside of the formal in-school frame. In this definition, STEAM learning is the multidisciplinary integration of all the subjects – Science, Technology, Engineering, Arts and Mathematics – that leads to the development of real world solutions to relevant problems in a contemporaneous context. The Scientists for Tomorrow initiative was developed and is now implemented following this framework.

Education in STEM - Science, Technology, Engineering and Mathematics - has received growing attention over the past decade, with calls both for greater emphasis on these fields and for improvements in curricula and instruction within and across them. Multiple reports and research support the premises that improving STEM education can lead to a generation of more qualified personnel able to direct and propel the "nation's innovative capacity." [1]

Despite the increased attention to STEM/STEAM in policy and funding arenas, there remains some confusion about STEM/STEAM, its individual subjects, the combination of its subjects, and even what constitutes as falling under the umbrella of STEM/STEAM. The looming question remains: is STEM/STEAM education the representation of a vision where individuals can comprehend the how all STEM/STEAM subjects intertwine and therefore should there be more emphasis on integrating these subjects when taught?

Looking to the New Generation Science Standards, it is possible to visualize efforts made to connect the four or five core subjects. Still, curriculum today is based in the learning of discrete areas, making the cross-disciplinary approach a challenge for current educators. On the other hand, according to the Federal Inventory of STEM education, 2011 [2], "Agencies used different criteria for what to list as a "STEM education program." Some agencies listed only programs primarily concerned with STEM education while others included all education or research programs that had some STEM education part, however small."

Then, it is also available in this inventory a definition of STEM/STEAM education that by themselves is not well defined and not provide clarity:
"STEM includes physical and natural sciences, technology, engineering, and mathematics disciplines, topics, or issues (including environmental science education or environmental stewardship). We recognize that various different and usually broader definitions are used for "STEM." [1]

To be able to assess if the participants and the out-of-school-time organizations' leadership have had, after the intervention, a positive change in their attitude and knowledge regarding STEAM subjects and potential future careers, then, it in necessary, to establish a working interpretation of what STEAM education looks like.

In the quest to define criteria to what is STEAM education, the Scientists for Tomorrow initiative explored existing programs with declared intentions to promote STEM or STEAM education. At Virginia Tech's School of Education, Integrative STEM Education is operationally defined as "the application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels. [3]

"STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy." [4]

When STEM programs (in its multiple definitions) started to emerge in the field, many voices started also to express the need to introduce the creativity in the learning process. Schools cannot continue to teach isolated disciplines based on simple reductionism. Science, Technology, Engineering, and Mathematics (STEM) should be integrated together with the Arts to promote creativity together with rationalization, and move to STEAM (with an "A" for Arts). [5]

Also, according to Robinson and Baxter [6] the need of the interdisciplinary work between Arts and STEM is well defined but the true interaction in the classroom between STEM and A(rts) is rarely appearing although there are fundamental parallels between the style and creative thought processes of engineers and visual artists. It is possible to see that working in a context where the Arts and STEM can help to improve critical and creative thinking when encouraging innovation. Following this line, it can be suggested that the STEAM model breaks old paradigms regarding traditional education, opening the learning experience from the topic-oriented organization to the contextually interdisciplinary open-ended learning process.

With the pedagogical STEAM reference frame in mind, it is important to also analyze the context of where the out-of-school-time STEAM learning takes place. The implementation of the Scientists for Tomorrow initiative's STEAM program takes place in collaboration with out-of-school-time organizations, outside of the formal education frame.

A generic definition of out-of-school-time programs is: initiatives for social learning, mentoring, and internships that take place before and after school hours, including weekends and summer. These programs are structured opportunities for school-aged youth that can complement, and in many cases supplement, the learning, physical and artistic activities are taking place in the regular school day. The out-of-school-time programs are generally provided by schools, community and faith-based groups, youth-serving organizations, cultural institutions and city/state agencies.

The definition of out-of-school-time programs can be also less generic. In the case of the Nevada Afterschool Network (NAN), in addition to the presented frame, out-of-school-time programs operate for a pre-determinate length of time (ten hours or more a week) on an ongoing basis serving a specific population (K-12 children).

It is possible to see that regarding the time frame and the structure of the out-of-school-time programs, these programs are not very different from the formal or in-school frame of learning. At a first glance, out-of-school-time programs can be seen as a natural extension of the in-school frame.

But there is a big difference between the in-school and out-of-school-time framework. First, the formal, in-school education system has a compulsory state-based attendance law [7]. Children must attend school, whereas out-of-school-time programs do not have any legal requirement to drive attendance. The fact that out-of-school-time programming does not have law-enforced attendance requirements has an important impact in the logistics of the programs, the organizations running them and the sources of funding available. These factors then strongly impact the potential participation of youth in these types of programs.

In the case of public schools, programs provided during in-school time frames are cost-free for the students and transportation issues are addressed as an integral part of the in-school frame under the responsibility of the education system. Out-of-school-time programs frequently incur costs, generally covered by the out-of-school-time organization through grants or other revenues, and usually require transportation to be covered by the participants [8]. These factors may determine the feasibility of different social groups to embrace the participation of their children in out-of-school-time programs, in particular for low-income families who may not be able to afford participation in - or provide transportation to - out-of-school activities.

A key component in the development of the out-of-school-time framework is that these programs should generate a positive atmosphere, conducive to learning and exploring, that does not resemble or look like the traditional school setting where students spend the vast part of their day [9]. For many students, as presented in the report on the "2009 High School Survey of Student Engagement," in-school framework is not the place where they want to be and learn. More than 66% of the surveyed students asserted that they are bored every day. A trend identified in this survey was that an open-ended question, Question 35, resulted in negative feedback. "Negative comments about schools were quite common in response to Question 35. Students shared their general dislike of their school, as well as particular aspects of their school that they felt had a negative impact on their work, learning and development."

To ensure that the out-of-school-time experience will have a positive impact on youth, the out-of-school-time framework needs to be developed to deliver services "in a way that provides youth with opportunities for choice, independence, flexibility and social experience. It would also seem important to create an atmosphere where youth can make mistakes without fear of judgment and without the pressure of time. Extending time-on-task will accommodate different learning styles and help promote learning with understanding." [9]

In summary, it is possible to define that STEAM-oriented out-of-school-time programming is a voluntary and structured framework conducive to learning STEAM contents outside of the formal in-school frame. In this definition, STEAM learning is the multidisciplinary integration of all the subjects – Science, Technology, Engineering, Arts and Mathematics – that leads to the development of real world solutions to relevant problems in a contemporaneous context. The Scientists for Tomorrow initiative was developed and is now implemented following this framework.

The Scientists for Tomorrow Initiative

The Scientists for Tomorrow (SfT) initiative was developed by the faculty and staff of the Science and Mathematics Department – Columbia College Chicago in partnership with several Chicago-based, out-of-school-time organizations and local informal science education institutions like the Museum of Science and Industry, The Field Museum and Garfield Park Conservatory. The development of this initiative started in 2009 with it officially launching in August 2011 when the program received an award from the National Science Foundation – Informal Science Education (NSF-ISE award # 1114165), providing the initiative with funding and resources to run for two years. Today the SfT initiative is on its sixth year.

The goal of the Scientists for Tomorrow (SfT) initiative is to address the opportunities articulated by the Informal Science as well as to promote urban youth in Chicago to be aware of, engaged in, and to develop skills related to STEAM subjects, fields and careers. The end goal is for students to utilize these learning opportunities to make informed decisions when choosing their future education and career paths.

The Scientists for Tomorrow Initiative Objectives

The objectives of the Scientists for Tomorrow (SfT) initiative are designed to provide different audiences access to STEAM-related learning opportunities including youth participants, parents, teachers and staff of out-of-school-time organizations.

1) Ubiquity: Youth program participants will learn STEAM content and skills in an out-of-school-time environment that will be reinforced in the home and institutional settings through the family, community centers, and museum/conservatory components of the program;

2) Equity: The program will develop a learning infrastructure specifically targeted to minority and other non-dominant groups; its curriculum will be made available to organizations and communities outside Chicago with similar demographics that traditionally lack of access to science resources;

3) Compelling experiences: The program will provide youth, their families and communities with opportunities to access powerful learning experiences at several Chicago informal science education providers (science museums and a conservatory) designed to promote awareness of science and technology and support classroom experiences;

4) Flexible assessment: The program will contribute to the body of knowledge about how learners can demonstrate their knowledge and skills without high-stakes tests;

5) Abundance of educators: Through the resources of Columbia College Chicago, the SfT initiative coordinators will instruct volunteers, graduate and undergraduate students and staff of out-of-school-time organizations on informal science education practice and curriculum, providing them with the opportunity to gain teaching experience in informal settings, as well as professional development.

Scientists for Tomorrow in the Out-of-School-Time Organizations - Methodology:

The implementation of the SfT initiative in out-of-school-time organizations is based on four connected activities:

1. Community Partner Meetings:

The SfT initiative is a partnership between the academic institution, out-of-school-time organizations, and informal science education venues, such as museums. The success of the program is based in the commitment of all the partners to fulfill their part in the implementation and responsibilities of the initiative. To ensure the communication and understanding of each partner's role in the program, SfT organized "Community Partner Meetings" twice a year, one in August before the start of the academic year where all the tasks and responsibilities of each partner are presented and clarified as needed, and one in December, to assess the development of the initiative in the out-of-school-time organizations and develop strategies for overcoming common problems (e.g. low parental involvement, recruitment strategies). These meetings are also oriented to facilitate the exchange of experiences between the leadership of different out-of-school-time organizations.

2. Implementation of the initiative's programs in the out-of-school-time organizations:

The Scientists for Tomorrow initiative's model divides the academic year into three, 10-week sessions: Fall (October-December); Winter (January-March) and Spring (April-June). Due to the fact that each out-of-school-time organization has a different structure for its offered summer programs, the SfT initiative does not offer a standard module for the Summer period. Each session explores a different module such as "Alternative Energies," "Physics of Sound and Mathematics of Music," "People and Plants," "Introduction to Robotics" and "Astronomy." Before each session starts, the SfT initiative provides more than 15 hours of professional development for all of the instructors involved in the program. All instructors additionally have access to lesson plans and video tutorials the SfT initiative's website (www.scientistsfortomorrow.org).

Each session includes 10 weekly, 90-minute classes exploring the modules. In each module, the participants develop a final product they can take home, e.g. in "Alternative Energies," the participants build a solar-powered car and in "Physics of Sound and Mathematics of Music" the participants build a monochord with a Pythagorean scale, a major chord wind-chime and a well-tuned Diatonic Xylophone. After the 10 meetings, each out-of-school-time organization develops its own end-of-module celebration where they invite parents and friends to celebrate the accomplishments of the youth in their own community center.

3. Family Science Days:

The SfT initiative, in partnership with informal science education venues, organizes a full day of activities in a selected museum/learning institution to celebrate the culmination of a module. This celebration is known as Family Science Days. The partner museums/learning institutions open their doors to SfT initiative participants and their families at no cost and dedicate specialized workshops and activities for the participants. The main idea for these events is to provide a free and different environment where parents and children can learn together. ISE venues partners include: Museum of Science and Industry (December), The Field Museum (March), and Garfield Park Conservatory or the Peggy Notebaert Nature Museum (June). In addition, the SfT initiative collaborates with Trio Program at the Center for College Access and Success (CCAS) at Northeastern Illinois University (NEIU) for the annual STEAM Conference where the children and parents of the out-of-school-time organizations participating in the SfT initiative present STEAM-oriented workshops. In 2015 and 2016 the conference included 40 parallel sessions with more than 1,200 participants in 2015 and 900 in 2016. The STEAM Conference serves as an alternative assessment of the activities and learning that took place in the out-of-school-time organizations during the academic year.

4. Evaluation:

To gauge the development of the program, the SfT initiative designed and implemented an external and internal evaluation procedure. The external evaluation was developed by Dr. Judith Lederman from the Mathematics and Science Education Department – Illinois Institute of Technology. Coordinators of the SfT initiative developed the internal evaluation.

For the external evaluation, each participant in each module takes a pre and post content test as well as a pre and post attitude towards STEAM survey. Program instructors and leadership of participating out-of-school-time organizations are also interviewed. The content tests were developed according to the module contents and adapted by the external evaluator for face and content validity. The attitude survey was selected by the external evaluator.

For the internal evaluation, program instructors are asked to maintain journals describing their experiences implementing the modules within their organizations. The SfT initiative uses these journals to gauge the development of the program throughout all of its sites on a daily basis. Based on the self-reporting of the instructors through the journals, coordinators of the SfT initiatives are able to identify and provide guidance as needed, as well as provide additional professional development opportunities when requested. This flexibility in responding to instructors' needs in real time generates a positive environment that leads the instructors to feel more confident in their roles as facilitators.

Instructors recorded one journal report per module activity that summarize:

1) Goals for the activity;
2) What worked well during the activity implementation;
3) What did not work well during the activity implementation;
4) Whether or not they attained their goals for the activity; and
5) Any other comments or suggestions related to the activity

The availability of this information facilitates prompt interventions at the time of need for instructors and enables an easier and more successful implementation of the program by the instructor.

Development of the SfT initiative

The seeds for the Scientists for Tomorrow initiative started in 2009 when, at a request from several out-of-school-time organizations, the author started exploring how to effectively implement STEAM activities in out-of-school-time environments. In this first year, the module "Alternatives Energy" was developed and tested in two community centers with two groups of 18 and 16 participants from 6th through 8th grade. The success of the implementation was measured by participants' level of engagement and commitment to attending the weekly meetings. At the end of the module, the participants were asked to reflect on the program, especially about the following points:

1) If they felt they like to work in STEAM topics in their out-of-school-time organizations; and

2) If they would have liked to more regularly participate in STEAM activities during their out-of-school-time programming.

The participants' responses showed that the majority (82%) indicated that they would like to participate in additional STEAM experiences. When the leadership of the out-of-school-time organizations was approached to continue the SfT initiative, the lack of resources appeared as the impediment to continuing the program.

For this reason, the Scientists for Tomorrow initiative applied for a National Science Foundation – Informal Science Education grant to support further exploration of the out-of-school-time STEAM experience, to expand the number of organizations participating in the initiative, and to test the initiative's sustainability.

The original SfT initiative grant, awarded in August 2011, provided services to 15 out-of-school-time organizations, 210 middle school students per quarter, 105 parents, and three annual family events for the period of two year. The out-of-school-time organizations chosen to take part in the SfT initiative through this grant are all affiliated with public schools that serve minorities (70% Hispanic and 30% African American) from low-income communities. The grant covered all expenses for implementing the program for two years. By September 2011, 14 sites starting the implementation of the module "Alternative Energies," following with the implementation of the module "Physics of Sound and Mathematics of Music," and the third module "People and Plants."

During the first year of the grant, the Scientists for Tomorrow initiative presented its model in several conferences and community meetings. As a result, many out-of-school-time organizations expressed interest in participating, sparking the development of a self-sustaining model for the initiative. Under the supervision of the SfT team, the program grew the number of out-of-school-time organizations participating in the program, in addition to the ones already funded by the National Science Foundation. Under the self-sustained initiative, the additional out-of-school-time organizations were responsible for financing the materials and the instructions needed to execute the SfT initiative. In return, the SfT initiative provided the professional development opportunities for instructors and supported the instructors on-site to ensure the academic and logistic progress and success of the program. After the National Science Foundation grant expired, the SfT initiative continued partially funding seven original participating out-of-school-time organizations through a third and forth year through no cost extensions (2013-2015). Today, in the SfT initiative's sixth year, the SfT initiative is self-sustained. The resources needed for the implementation of the program are provided by the out-of-school-time organizations participating.

One important lesson learned by the SfT team during the implementation of the program was that the majority of out-of-school time organizations did not have STEAM activities available for parents and families of its participants. Parents were not aware of what STEAM is or how their children could benefit through participating in STEAM activities and therefore could not help motivate their children's participation in the activities. For these reasons the SfT initiative developed a complementary program – SfT for parents, which took the modules developed and taught it to groups of parents. By participating in a similar program to what they're children were participating in, parents had an extended and stronger investment in the SfT initiative programs for their children. The parents became the best ambassadors in their community to promote STEAM education in the formal and informal learning environments.

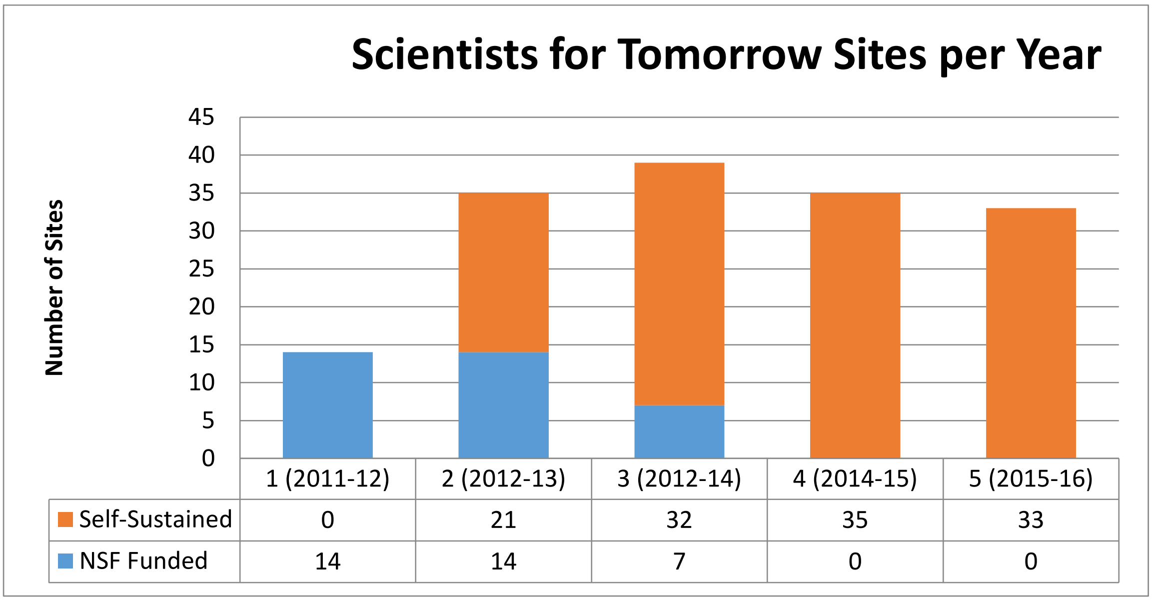
Throughout the six years of the program, with the collaboration with informal science education venues such as museums, the SfT initiative organized 16 Family Science Day events for parents and children. The family events took place at the Museum of Science and Industry, The Field Museum, The Garfield Park Conservatory, The Lyric Opera, The Peggy Notebaurt Nature Museum and the STEAM Conference. In these venues participants and families attended specialized workshops, exhibits and youth-led activities that provided them with resources for replicating lessons throughout their communities.

Of the different Family Science Day events programed, the largest is the annual STEAM Conference, which offers middle school and high school students with the opportunity to attend and participate as practitioners in a conference setting. Founded in 2010, the conference was developed through the collaboration between the Scientists for Tomorrow initiative from the Science and Mathematics Department – Columbia College Chicago and the TRIO Program from the Center for College Access and Success (CCAS) – Northeastern Illinois University (NEIU). Annually, about 1,200 children and parents attend the conference and participate in 40 parallel workshops, of which 16 are led by SfT participants and one is led by the parents class of the SfT initiative.

Implementation of the SfT program 2011-2016 in numbers

Year	Out-of-school-time organizations (NSF Funded)	Out-of-school-time organizations (Self-sustained)	Number of instructors	Number of youth participants	Number of parent participants
1 (2011-12)	14	0	10	545	0
2 (2012-13)	14	21	34	767	0
3 (2012-14)	7	32	33	958	0
4 (2014-15)	0	35	44	732	26
5 (2015-16)	0	33	34	623	22

Table 1 – Scientists for Tomorrow funding sources, Number of Instructors and Participants per year



In summary, the Scientists for Tomorrow initiative was created as an idea to promote high-quality STEAM academic enrichment in informal settings for out-of-school time in community organizations. Today the program is well established among the participating out-of-school-time organizations throughout the Chicago-land area. Funding for this program remains the responsibility of all the partners involved. The SfT program is currently serving more than 600 middle school (ages 10 to 13) children and 50 parents from underserved, low-income communities per year in a self-sustained model.

Evaluation of the Scientist for Tomorrow initiative 2011-2016

The main goal of the evaluation is to gauge if there is a significant impact in the content knowledge and the attitude towards STEAM subjects and their potential careers. The evaluation of the program is composed of two elements: the external evaluation and internal evaluation.

The external evaluation was designed and implemented by Dr. Judith Lederman from the Mathematics and Science Education Department – Illinois Institute of Technology. This evaluation includes a STEAM attitude survey and a content test designed for each specific module. These instruments were developed and tested for validity and reliability by the external evaluator.

At the beginning of the implementation of each module, typically week one and two of instruction, the participants take a test and survey evaluating their content understanding and attitude towards STEAM. The same test and survey is then taken on the last week of the module. To ensure the anonymity of the evaluation, the test and surveys were double-blinded. (See appendix 1 Test and Survey Samples).

Each module has its own unique content knowledge test. The "Alternative Energy" test has a maximum score of 21 points (21 multiple choice questions with four answers to choose from, only one answer being correct per question). The "Physics of Sound and Mathematics of Music" test has a maximum score of 13 points (13 multiple choice questions with five answers to choose from, only one answer being correct per question). The "People and Plant" test has a maximum score of 14 points (14 multiple choice questions with four answers to choose from, only one answer being correct per question).

Summary data collected – Content Knowledge per Module per Year

Year	Module	Number of participants	Number of pre-module tests collected	Pre-module score	Post-module score	Paired pre-post test significant difference
2011-12	Alternative Energy	202	57	N=163 8.53 SD=3.53	N=82 10.27 SD=3.79	Pre(57)=9.59 SD=3.5 Post(57)=10.90 SD=3.2 t(57)=3.2 P<0.01
	Physics of Sound	118	53	N=104 3.24 SD=1.8	N=118 3.70 SD=2.14	Pre(53)=2.36 SD=2.16 Post(53)=3.44 SD=2.05 t(53)=3.11 p<0.01
	People and Plants	157	78	N=142 5.94 SD=2.69	N=94 6.32 SD=3.02	Pre(78)=5.84 SD=2.68 Post(78)=6.48 SD=3.01 t(78)=2.19 p<0.01
2012-13	Alternative Energy	313	143	N=186 8.4 SD=3.24	N=119 8.24 SD=2.18	Pre(143)=8.35 SD=2.98 Post(143)=11.38 SD2.34 t(143)=6.39 p<0.01
	Physics of Sound	341	107	N=303 4.39 SD=2.08	N=155 5.26 SD=2.06	Pre(107)=4.97 SD=2.03 Post(107)=5.13 SD=1.81 No significant difference
	People and Plants	95	45	N=74 5.28	N=66 5.53	Pre(45)=5.40 SD=2.54 Post(45)=5.53 SD=2.52

				SD=2.53	SD=2.59	No significant difference
2013-14	Alternative Energy	337	195	N=287 13.13 SD=1.95	N=231 14.26 SD=2.06	Pre(195)=13.02 SD=2.31 Post(195)=14.75 SD=2.18 t(195) 10.46 p<0.01
	Physics of Sound	246	104	N=181 3.2 SD=1.61	N=169 4.82 SD=1.51	Pre(104)=4.21 SD=2.17 Post(104)=5.32 SD=2.2 t(104)=5.1 p<0.01
	People and Plants	87	63	N=84 4.13 SD=2.16	N=66 7.2 SD=2.64	Pre(63)=4.71 SD=2.13 Post(63)=7.03 SD=1.94 T(63)=8.645 p<0.01

Table 2 – Content Knowledge Pre and Post test per module per year

Year four of the Scientists for Tomorrow initiative (2014-15) was the second year it was running on the National Science Foundation's no cost extension, therefore the SfT initiative did not have available resources to effectively collect the pre- and post-model tests for the external evaluation. No external evaluation was implemented in year five of the SfT initiative (2015-16).

From the data presented for the years that external evaluation data was collected, it is possible to see that the SfT initiative has had a modest impact in the content knowledge of the participants. In all the cases examined with the exception of two, the paired t-test for the students that completed both tests showed a statistical significant change.

Attitude towards STEAM survey

In each module, participants took a STEAM attitude survey at the beginning and the end of the module. A summary of the results of the STEAM attitude survey (19 questions in total; 5-point Likert scale) are presented below:

Year	Module	Participants	Paired survey collected	Enter survey score	Exit survey score	Paired enter-exit survey significant difference
2011-12	Alternative Energy	238	50	N=156 71.88 SD=10.2	N=72 73.29 SD=11.47	Enter(50)=72.1 SD=10.5 Exit(50)=73.9 SD=9.7 t(50)=1.4 P<0.18
	Physics of Sound	164	52	N=146 73.1 SD=11.6	N=118 74.24 SD=11.54	Enter(52)=72.6 SD=12.2 Exit(52)=73.55 SD=11.32 Not significant
	People and Plants	157	34	N=67 71.6 SD=12.3	N=69 74.3 SD=12.0	Enter(34)=73.3 SD=11.1 Exit(34)=73.4 SD=12.6 Not significant
2012-13	Alternative Energy	313	143	N=156 71.9 SD=10.2	N=172 73.3 SD=11.5	Enter(143)=67.5 SD=11.3 Exit(143)=69.9 SD=11.4 Not significant
	Physics of Sound	341	107	N=297 70.2 SD=12.0	N=155 71.2 SD=10.9	Enter(107)=70.4 SD=12.3 Exit(107)=70.5 SD=11.6 No significant difference
	People and Plants	95	45	N=74 69.8 SD=11.8	N=66 71.2 SD=10.3	Enter(45)=70.4 SD=10.7 Exit(45)=72.5 SD=12.5 No significant difference

Table 3 – Attitude towards STEAM survey – Pre and post survey per module per year

The data collected from the STEAM attitude surveys shows that there is not a significant difference between the enter survey and the exit survey. One of the possible explanation can be that rather than in a formal education setting, compelled enrollment in school for example, the participants of the SfT initiative are self-selected students that choose to be part of the program. For this reason their attitude towards STEAM are positive from start, having high scores in enter survey. There is a slight score improvement after the implementation of all modules, though not high enough to be statistically significant.

A noteworthy change in attitudes was found for participants labeled as "frequent participants," reflected by their participation in at least four of the six total modules offered over the course of the two years. For frequent participants, there was a statistically significant difference in their attitude gain scores, in general and across the various subscales in comparison to their peers. An interesting point regarding the "frequent participants" is that these teens started to take by themselves more leadership roles during the activities in the centers and acted as interns, helping in the setup, and leading other teen during the implementation of the program.

Concerns regarding the test and the surveys

Observers from the evaluation team expressed some concern regarding the implementation of the evaluation in the field, in particular the way the test and the surveys were taken by the participants. Despite the efforts of the proctors to explain the participants about the importance of the test and the survey,

1) Many students expressed difficulties understanding the format of the test and because it is not a "school test" with personal consequences, after making an initial effort to answer the questions, many students gave up and completed the test by selecting random choices.

2) Many students expressed that they did not like the fact that they need to take a test during their out-of-school time and therefore did not invest any effort in answering the questions. To address this point, the SfT initiative is currently developing a game-type test to assess the knowledge of the participants in a more dynamic and less threatening environment.

In addition to student evaluations, the external evaluator conducted interviews with the instructors, resource coordinators and directors from the out-of-school-time organizations participating in the SfT initiative. Here are excerpts from the external evaluator's final report:

"Over the course of the fourth year of the program, and in comparison to the third, the increased fidelity of implementation evidenced by participant instructors in their enactment of the written modules lends further evidence to the efficacy of the training provided by the program; a noted emphasis of the director's following the second year. It was clear that the challenge surrounding fidelity of implementation were formidable given the scope of the project, but Marcelo Caplan (Co-PI and director of the project) and his staff should be commended for their emphasis in year four on providing open lines of communication regarding the needs of the centers, their coordinators, and the instructors, in addition to providing a more systematic procedure for documenting participation and for gleaning insight into challenges faced by all stakeholders on a week-to-week basis. These “forms” included sections related to activity descriptions, instructors’ goals for each session, an overall critique of the activity, suggested changes and/or improvements for the lesson, needs for next session, and an evaluation form that details instructors’ perceptions of participants’ performance for the day.”

Regarding the position of the out-of-school-time organizations in reference with the program, the external evaluation findings are summarized in the following paragraph:

“As was the case at the conclusion of the third year of the program, community center directors spoke glowingly of not only the tireless work of SfT director and his staff, but also of the perceived benefit for program participants, citing the positive feedback from both parents and students alike. Furthermore, without exception community center directors spoke of their desire to continue the Scientists for Tomorrow program if given the opportunity.”

As previously mentioned, the SfT initiative staff implements the internal evaluation. To assess the development of the programs in the participating out-of-school-time organizations, the SfT initiative developed a journal for instructors to complete after each lesson. During the first year of the SfT initiative, instructors completed a paper report and many instructors expressed that the inconvenience of the paper report prohibited them from completing the internal evaluation. Following that feedback, the SfT initiative then developed an online journal where the instructor feedback, and SfT staff response, could be shared instantly. This now allows the SfT initiative staff to address the needs of the instructors immediately. Through these journals, the SfT initiative staff additionally receives information about what works well, what part of the lesson plan needs to be reviewed and improved, which skills the participants have difficulties acquiring, etc. Based on the information from hundreds of journal entries collected, the SfT initiative staff continues to improve the lesson plans for each module. All updated lesson plans are available for the instructors in a secure part of the SfT initiative’s website.

To date, one of the biggest findings of the internal evaluation is that many instructors, most of whom are typically non-STEAM professionals, learn the content and pedagogy in the professional development opportunities but feel insecure when it comes to implementing the STEAM lessons. For this reason, the SfT initiative developed a set of video tutorials covering the content of the modules. At the time of this publication, the SfT initiative had developed more than 50 video tutorials. Instructors can these videos at any time and are most handy before an instructor has to present a topic or activity to their group. The feedback from the instructors about the videos has been positive and some instructors also utilize the video-tutorials during their lessons.

The SfT initiative staff periodically surveys the instructors, resource coordinators and program directors from the participating out-of-school-time organizations in the SfT initiative to gauge the development of the program in their organization. From the analysis of the qualitative data collected during the five years of the implementation of the initiative, it is possible to see the following constructs:

1) The out-of-school-time organizations incorporated STEAM academic enrichment as part of their curricula;
2) The out-of-school-time organizations are committed to finding resources to financially sustain the initiative within their program

3) The out-of-school-time organizations identify the SfT initiative as a provider of high-quality STEAM programming; and
4) The SfT initiative contributes to increased participation of youth and their parents in other STEAM-related activities provided by the out-of-school-time organization

The SfT initiative's latest survey, composed of 15 statement 5-point Likert scale (1 strongly disagree, 5 strongly agree), was sent to the 78 out-of-school-time organizations' directors, resource coordinators and instructors working with the initiative in the fall of 2016 through a Google form. The survey was open for two weeks and received 43 answers (55% return).

The table below shows the results of the latest CBOs' membership participating in the Scientists for Tomorrow program (average per category of participant, CBO Director of Education, Site Director, Resource Coordinator and Instructor).

	N	How many years are you involved in the partnership with SfT	The Scientists for Tomorrow (SfT) model contributed to introducing STEAM activities as an integral component on your Out of School Time curriculum	The bi-annual Community Partners meeting contributed to increasing the capacity of your community center leadership to successfully implement STEAM curriculum	The SfT model helped your community to increase access to high quality STEAM programs for your youth	The SfT model provides an important contribution to make the program in our community sustainable	The SfT model is having a positive impact in your community organization	The SfT model motivate youth to be involved in STEAM activities in the community center	The professional development provided by SfT enhances the knowledge of the community members and prepares them to be efficient STEAM instructors in the communities
Director of education	8	4.00	4.75	4.13	4.75	4.25	4.50	4.50	4.50
Site Director	8	4.13	4.63	3.75	4.50	4.00	4.38	4.38	4.75
Site Coordinator	13	2.54	4.23	3.77	4.54	4.15	4.38	4.46	4.54
Instructor	14	2.64	4.64	4.29	4.79	4.64	4.86	4.71	4.64

	N	The Family Science Days organized by SfT motivate parents to be involved in activities in the community center	The STEAM conference motivates your youth to be involved in SfT	The main problem to run the SfT program in the community center is the quality of the curriculum	The main problem to run the SfT program in the community center is the lack of good instructors.	The main problem to run the SfT program in the community center is the cost of the program	The main problem to run the SfT program in the community center is the uncertainty of the funding sources	The enrollment of participants in the SfT program is popular in your community center
Director of education	8	4.38	4.75	1.38	3.00	3.00	4.00	4.13
Site Director	8	3.75	3.88	1.25	3.50	3.50	3.75	3.63
Site Coordinator	13	3.69	4.23	2.15	2.46	3.38	3.85	3.85
Instructor	14	3.86	4.21	1.57	1.64	2.50	3.21	4.14

Table 4 - Results of the Fall 2016 CBO's survey

From the data collected in the survey it is possible to identify the following trends:

1) The SfT initiative has contribute to introduce STEAM activities as part of the regular out-of-school time programming.
2) The SfT model provides a high quality STEAM curriculum, provides opportunities for community members to take leadership roles in a sustainable mode

3) The major problem regarding the implementation of the program in the out-of- school time sites is the access to funding sources.

Conclusion

In summary, the data presented from the external evaluation strongly supports the hypothesis that the Scientists for Tomorrow initiative is an effective out-of-school-time program. The SfT initiative promotes STEAM in communities by implementing well-developed content modules for students, promoting parents participation in out-of-school-time activities like Family Science Day, and increasing the capacity of out-of-school-time organizations to better serve their communities through a large series of professional development opportunities for their instructors and resource coordinators.

In the same trend, leadership from out-of-school-time organizations involved with the SfT initiative expressed their satisfaction at having SfT programming on their sites and expressed a continued commitment so funding the initiative in their communities.

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Appendix 1 –Test and Survey Samples

Alternative Energy Module

Survey and Pre-test

First Name:

Last Name:

Site:

Age:

Gender: Male Female

Enter Season and Year

____________________ 20_____

PRINT THIS PAGE

Code ______________________________

What I think about Science Technology Engineering and Mathematics

Please complete the following survey. For each item below, circle the number that best represents your feelings towards the statement. Circle 5 for if you strongly agree with the statement, 4 if you agree with the statement, 3 if you are not sure about the statement, 2 if you disagree with the statement and 1 if you strongly disagree with the statement.

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1. Science is an important subject to learn.	1	2	3	4	5
2. Science is hard for me to understand.	1	2	3	4	5
3. Most people do not need to understand science.	1	2	3	4	5
4. I do not enjoy science.	1	2	3	4	5
5. I am interested in a career in science.	1	2	3	4	5
6. Science is easy for me to understand.	1	2	3	4	5
7. I think science is important but I do not like to learn about it.	1	2	3	4	5
8. I do not enjoy solving problems.	1	2	3	4	5

9. I have many ideas about designing and building new things.	1	2	3	4	5
10. I think it is enjoyable to solve problems.	1	2	3	4	5
11. I think it is fun to build things.	1	2	3	4	5
12. I think technology is important but I am not interested in learning about it.	1	2	3	4	5
13. Learning about technology is exciting to me.	1	2	3	4	5
14. Math is important for everyone to study.	1	2	3	4	5
15. Many people use math in their everyday life.	1	2	3	4	5
16. Math is easy to learn.	1	2	3	4	5
17. I really do not care about learning math.	1	2	3	4	5
18. I enjoy math.	1	2	3	4	5
19. I think math is important, but I do not like to study it.	1	2	3	4	5

Code ______________________________

Energy Test

In order to learn what you already know about energy, please read each question below carefully and circle the best answer. This test does not count for a grade. Try to do your best.

1. **Energy is __________.**
   a. a light bulb
   b. an animal
   c. the ability to do work
   d. an electric circuit

2. **Energy can be__________.**
   a. changed from one kind to another
   b. created and destroyed
   c. created but not destroyed
   d. used over and over again

3. **Energy is needed to __________.**
   a. grow
   b. move things like boxes and cars
   c. power lights, televisions, cell phones and computers
   d. all of the above

4. **Electrical energy is very useful because it can be converted to __________.**
   a. light energy, heat energy and water
   b. light energy, heat energy and mechanical energy
   c. matter and energy
   d. atoms and molecules

5. **Which of the following is an electrical <u>conductor</u>?**
   a. metal
   b. plastic
   c. wood

6. **Which of the following would be an electrical <u>insulator</u>?**
   a. a copper wire
   b. a piece of rubber
   c. a metal pipe

Code ______________________________

7. **At your house, the electrical power that you use is measured in watts. How would you calculate the watts needed to power a television?**

d. multiply voltage times current
e. multiple voltage times resistance
f. add the conductor to the insulator
g. add volts to amps

8. **When designing machines that are powered by electricity, engineers should think about __________.**

h. designing machines with increased energy use
i. designing machines with decreased energy use
j. designing machines that use no energy
k. designing machines that use no electricity

9. **If you see the metric prefix <u>kilo</u>, such as in <u>kilo</u>watts or <u>kilo</u>grams,** it means __________.

a. 10
b. 100
c. 1,000
d. 1,000,000,000

10. **Which metric label would you use when you measure the <u>length</u> of a car?**

a. grams
b. liters
c. seconds
d. meters

11. **Which metric label would you use to record the <u>mass</u> of a car?**

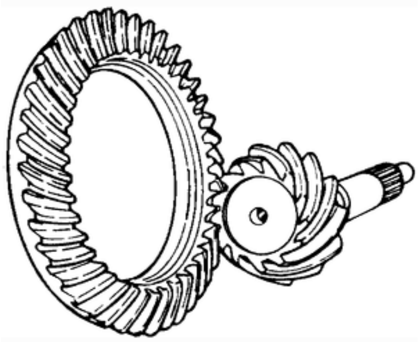
a. grams
b. liters
c. seconds
d. meters

12. **What might you be doing if you are soldering?**

a. connecting two pieces of metal together
b. connecting pieces of wood together
c. creating fire
d. producing electricity

Code ______________________________

13. Look at this picture. Which statement best describes what is happening that could help a car move?



a. energy is being created as the gears move one another
b. mechanical energy is being transferred from one place to another
c. electricity is being produced by the gears
d. an electrical circuit is producing energy

Image retrieved from www.procarcare.com

14. A solar cell is often called a photovoltaic cell. Photo refers to _____ and voltaic refers to _____.

a. picture, battery
b. picture, voltage
c. light, electrical energy
d. light, battery

15. Ayesha has been conducting investigations with toy, metal cars. She thinks the lightest ones will travel the fastest. She has a scale, a timer and a ramp to use for her experiments. Which investigation will best help her test her idea?

a. Ayesha measures the weight of each car, places it at the top of the ramp, lets it go, and times how long it takes for the car to reach the bottom of the ramp.
b. Ayesha places each car at the top of the ramp, lets it go, and times how long it takes for the car to reach the bottom of the ramp.
c. Ayesha measures the weight of each car.
d. Ayesha measures the weight of each car, places it at the top of the ramp and lets it go.

16. If you want a photovoltaic (PV) cell to generate more electricity you would __________.

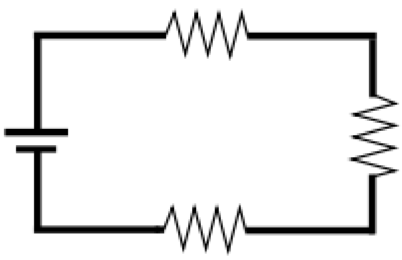
a. bring the light source closer to the PV cell
b. increase the area of the PV cell that is exposed to light
c. minimize the reflection of light off of the cell
d. all of the above are ways to generate more electricity`

Code ______________________________

17. One drawback of using solar energy to generate electricity is that sunlight must be available in order to create the electricity. One way around this problem is to __________.

a. plug your solar cell into an electrical outlet for several hours
b. use the solar cells to charge a battery that will discharge when you need the electricity
c. use electricity powered lamps to charge the solar cell when there is no sunlight
d. use running water to charge the solar cells if there is no sunlight

18. Look at the picture below. Determine which type of circuit this is.



a. series
b. parallel
c. uniform
d. none of the above

Image Retrieved from en.wikipedia.org/wiki/Series_and_parallel_circuits.

19. When the word <u>hybrid</u> is used, such as in <u>hybrid</u> car, this means that the machine uses __________.

a. only one source of energy
b. light energy and energy from the burning of gasoline
c. parallel circuits
d. more than one source of energy

20.Think about a flashlight. An advantage of using alkaline batteries over rechargeable batteries in the flashlight is that __________.

a. alkaline batteries can be used over and over again
b. with alkaline batteries, less wastes are produced after running the flashlight for many years
c. with alkaline batteries, no charger is needed
d. with alkaline batteries, the cost of running the flashlight for many years will be less

Code ______________________________

21. Developing solar energy in the United States is important because _.

a. there is no pollution produced with solar energy b. the sun is a renewable source of energy
c. solar energy is currently cheaper than using fossil fuels
d. it will provide jobs in other countries