Be a Scientist! Project Summary

Be a Scientist! is a broad implementation project that brings inquiry-based Family Science Workshops (FSWs), designed and taught by engineers, to under-served minority children in grades 1-5 and their families. Unique aspects are: 1) the rigorous training engineers undergo to communicate university research to the public; 2) the emphasis on parents learning science with their children; 3) the mutual learning model in which both the families and engineers benefit from "doing science" together. The model has been successfully implemented by Iridescent, a nonprofit organization, over three years at 76 sites in California, reaching 4000 low-income Hispanic and African-American families. We propose to scale the model to New York City with support from the New York Hall of Science and The Cooper Union to measure the effect of increasing magnitude, breadth and programmatic complexity on quality.

Intellectual Merit

Be a Scientist! will gather and disseminate data on implementing a scalable informal science education (ISE) program for underserved communities. This is an important area of research given the low level of participation in science within the underserved urban community. The research will address *three key challenges of the ISE field:* 1) identifying scalable methods of engaging minority audiences in science, technology, engineering and mathematics (STEM); 2) identifying cost-effective, sustainable methods of encouraging learning in between and after workshops; 3) developing instructor training and teaching strategies that enable participants to develop deep content knowledge.

STEM deliverables include implementation of 76 FSWs in Los Angeles and New York City reaching 1770 participants, 640 hours of STEM communication and ISE training to 140 student engineers, a replicable, engineer training program and an ISE curriculum for 20 physics-based workshops. Media deliverables include a social-networking website for parents, 10 science videos and five science T-shirt designs. We will research the feasibility of video coding as a tool to evaluate participant interest and engineer effectiveness. The project will also deliver an information visualization tool that will enable education organizations to make more data-driven, cost-effective decisions on recruiting minority families.

University-based research expertise will be provided by University of Southern California's Viterbi School of Engineering and The Cooper Union. ISE support will be provided by the New York Hall of Science (NYSCI) and the Natural History Museum (NHM) of Los Angeles. The project's external evaluation will be conducted by the Center for Children and Technology at the Educational Development Center. Overall project coordination and management will be provided by the nonprofit, Iridescent.

Broader Impacts

The primary audience is underserved, minority children (grades 1-5) and families from Los Angeles and New York City. The secondary audience is engineers who are trained to develop and implement the FSWs. The program is transformational for both audiences. Parents and children experience a positive change in their attitudes towards science as they realize how relevant and rewarding it is. They will also increase their sense of STEM self-efficacy as they realize that science is accessible to them as an interest, a hobby or a career. Instructing engineers develop a deeper understanding of their own field, a greater cultural sensitivity and improved science communication abilities. Impact of the program will be measured through external summative and formative evaluations, a longitudinal (5-yr) evaluation of the program in Los Angeles and through audio-visual processing & automated data interpretation.

The project will *strategically impact ISE* by: 1) creating sustained learning experiences that help ISE organizations truly engage with minorities; 2) bringing university-based research directly to the public; 3) enhancing learning by bringing valuable social capital to underserved communities; 4) developing technology-based evaluation and resource-allocation tools; 5) identifying factors that develop persistent participant interest in STEM; 6) developing a Parent Leadership Program that will help parents co-invest in and sustain the program post award.

Be a Scientist! Project Description

Be a Scientist! is a broad implementation project that will gather and disseminate data on implementing a scalable informal science education (ISE) program for underserved communities. We will scale an existing program that trains engineers to develop and teach inquiry-based Family Science Workshops (FSWs) to underserved families. The program has been successfully implemented for three years by a nonprofit Iridescent, in partnership with universities and ISE organizations. Key features of the model include: 1) communicating current science, technology, engineering and mathematics (STEM) to the public; 2) collaboration and diversity in "ownership" that enables underrepresented groups to see their own ways of sense-making reflected in the learning environments [1]; 3) encouraging deep learning through cognitive apprenticeships in which learners enter into long-term relationships with expert mentors; 4) individualization and learner choice; 5) building a supporting infrastructure through family and community involvement; 6) focus on sustainability and rigorous evaluation.

A. PROJECT RATIONALE

The FSWs are designed and taught by engineering undergraduate and graduate students to families at schools in the evenings. Topics illustrate the real-world applications of Physics and range from Cardiovascular Mechanics to Bird-flight Aerodynamics. Since July 2006, 200 engineers have undergone science communication training and conducted 132 workshops reaching ~4000 underserved children and parents. Be a Scientist!'s **goals** are to address three challenges that have emerged out of these experiences and are representative of the ISE field [2]:

ISE CHALLENGE 1 - To identify scalable methods of engaging minority audiences in STEM. Research shows that STEM public participation is generally skewed toward the dominant cultural group. We need to understand science learning in nondominant cultures to inform basic theory and to design meaningful, inclusive learning experiences [2]. We have fully implemented the program at 80 sites in three cities with two minority groups, but need to test the model for scale, breadth and complexity to develop a truly scalable, inclusive program.

ISE CHALLENGE 2 - To identify sustainable methods of supporting long-term learning. We need a cost-effective, technology-based method of reaching the families after the FSWs to ensure persistent STEM interest.

ISE CHALLENGE 3 - To enable families to develop deep content knowledge. Through regular pre and post tests we have observed that participants gain >40% in terminology and understanding scientific processes. However they are not able to transfer their learning to a new problem or generate causal explanations. The goal of this project would be to identify and develop engineer training strategies that enable families to develop a deeper understanding of the STEM content.

Our **approach** will have the following features:

Out-of-school-time programs were chosen as the venue for this program as they allow for sustained experiences with science, learner choice, low-stakes learner assessments and for reaching underrepresented audiences [2]. They also enable face-to-face interactions between the engineers and families that foster an "I can be a scientist!" feeling among the participants.

Strong STEM/ISE partners: The Viterbi School of Engineering at University of Southern California (USC) and the Albert Nerken Engineering department at The Cooper Union will be the STEM partners in Los Angeles and New York City, providing access to university-based research and engineering students. ISE partners will be the Natural History Museum (NHM) of Los Angeles and the New York Hall of Science (NYSCI), providing ISE training to the engineers.

Longitudinal evaluation of program in Los Angeles: We will provide FSWs to the same families at 10 partner schools each year and will follow them from grades 1-5. The goal would be to address *Challenge 2 and 3* and longitudinally evaluate the impact of the program.

Scalable, audio-visual data based evaluation: We will aid the evaluation of participant behaviors (activation levels of how strong or weak the affective engagement is, valence levels of how negative or positive the interactions are, and high level content/timing information of who is doing what and when) through audio-visual processing and automated, intelligent data interpretation. Current behavior based practice is based on manually generated observational coding of human interactions. Such coding can be expensive and extremely labor intensive, in the order of 10 times the actual session length. Automated data analysis will enable us to develop a scalable, cost-effective evaluation technique that could supplement expert evaluations with meta-feature streams based on machine reasoning of the raw observations.

STEM FOCUS

Through interactions with ~4000 underserved children and parents we have seen that the FSWs provide a transformational opportunity for families to be exposed to current science and experts while giving them the freedom to shape their own learning [3]. Key STEM features include:

Focus on current STEM research: The FSWs bring the most exciting and inspiring aspects of science directly to the public. Thus workshop topics include medical imaging, fluid dynamics, nanotechnology and material science. The program design is based on motivation theory, allowing participants to first discover the rewards of curiosity so that they will be motivated to persist and master the basics [4].

Family-directed learning: The FSWs aim to foster participants' intrinsic motivation and self-direction to learn so that they become lifelong explorers [2]. Since the participants' prior knowledge of the problem at hand is limited, engineers first introduce the core concepts through multi-media. After instruction, families have the freedom to evaluate and shape their learning [5]. For instance, in a session on bird flight aerodynamics, engineers may discuss the effect of wing shape on lift distribution and then give directions on the basic experiment. The experiment would be goal-directed and design constraints would be outlined. Families would have to design a glider that flies for 10 seconds using materials that present varying difficulty and learning levels. Families would have the freedom to build bird models out of tissue paper (advanced challenge) or poster board (beginner's challenge). After the experiment, engineers would lead a self-evaluation with the participants. Finally, they would share take-home resources that would enable families to spend more time in self-directed learning, selecting and studying the various materials, critically evaluating their findings, elaborating on knowledge acquired or correcting misconceptions [6, 7]. At the next session, engineers would ask families what direction the learning should take. As the families gain deeper knowledge, they would have more control in shaping the direction of their learning.

PUBLIC AUDIENCE - "I CAN BE A SCIENTIST!"

Los Angeles is one of the nation's capitals of economic deprivation with ~40% of residents unable to meet their basic needs, 1/3 of full-time workers earning less than $25,000/year and more than 20% of children living in extreme poverty. In addition, Hispanics and African Americans are 2.5 times more likely to be extremely poor as compared to non-Hispanic whites [8]. We will recruit 1st-5th grade low-income students from Los Angeles Unified School District (LAUSD), District 7 schools that serve 78% Hispanic and 21% African-American students with the goal to increase the representation of these communities in higher STEM education.

In New York City, we will recruit 1st-5th grade students from NYSCI's neighborhood, Corona, Queens, one of the most diverse communities in the nation. Over 100 languages are spoken in Corona and it is often the first stop for newly arrived immigrants. Nearly two-thirds of the community is foreign born, and over 90% speak a language other than English, with 78% speaking Spanish. The community is predominantly Latino from Dominican Republic, Mexico and Ecuador. Asians (primarily Indians and Chinese) make up 10% of the population. Poverty rates are higher than the rest of Queens, with over 21% of households below the poverty line [9]. Education levels are low among adults: 54% of the population over 25 lack a high school diploma or GED, and 34% have a grade education or less [9].

The scarcity of academic support, informal and formal mentorship, and academic role models within friend and family networks exacerbate the educational challenges that children from these communities face [10-16]. As a result, they are underrepresented in STEM [17-22]. Parents, universities and ISE organizations thus present a rich, untapped resource for improving childrens' engagement in STEM [23-25].

Appropriate approach for target audience: Numerous studies have established the link between parent involvement and improved student achievement, better school attendance, and reduced dropout rates [26-44]. However, other studies and our experiences indicate that although parents care very much about their children's education they face significant obstacles to being involved [38, 45-48]. In order to increase parent-involvement, we must address: low education levels [32, 33, 39, 45, 47, 49, 50], language [38, 46, 51-55], logistical issues (such as long working hours, multiple jobs [50, 56-58] or single parenthood [22, 39]), culture [17, 45, 59-61] and constrained communication between ethnic groups due to safety issues and mutual distrust.

The current model overcomes parent's low education levels by designing materials that enable them to develop their own skills while facilitating their child's learning. The language barrier is addressed by providing bilingual materials, on-site translators and by communicating with adults via bilingual children. The direct instruction piece during which the engineers introduce and explain the concepts is limited to 15 minutes to ensure the translation process is not tedious for English-speaking adults. Logistical issues such as lack of time are mitigated by providing meals so that adults can free up the required time from preparing dinner, involving all the children to remove child care costs and by holding workshops at convenient times and in safe, familiar locations (e.g. school sites and community organizations). We support interracial communications by creating a space that allows interactions in pursuit of shared goals [62].

The emphasis on cooperative learning is culturally attuned to Hispanic and African-American communities whose "collectivist" cultures can clash with the individualistic nature of most formal education. Collectivism focuses on "interdependent relations, social responsibility and the well-being of the group"[45]. We build on the support of the family through its emphasis on cooperative learning and by inviting all (toddlers to grandparents) to participate in exploration [20, 22, 50, 52]. Parents are invited to participate in a Parent Leadership Program (PLP) that gives them the skills to co-invest in the FSWs. They can opt to help in translation, organizing materials and facilitating FSW activities [22]. This opportunity enables them to develop and practice valuable skills of leadership and entrepreneurship in addition to helping them build their sense of self and collective efficacy.

Be a Scientist! will be successful if: 1) families demonstrate >80% gains in pre and post tests; 2) >80% of families in Los Angeles exhibit a persistent interest in STEM over five years; 3) Los Angeles parents co-invest in the FSWs and raise $1000/workshop in the project's fifth year.

ENGINEERING AUDIENCE - "MY WORK INSPIRES MANY"

The FSWs enable engineers to directly impact the STEM pipeline by serving as role models and providing meaningful science learning experiences to the public. The engineers develop their public speaking and leadership skills and a deeper understanding of their own field while communicating complex concepts to large, diverse audiences. The FSWs also add deeper meaning to the engineers' work through personal validation, connection and gratification from clarifying complex topics for the public. This model has proven to be very effective as the engineers devote significant amounts of time to the FSWs (80-100 hours/four months) for no tangible rewards, return year after year and become active, long-term volunteers bringing valuable social capital to high-need areas. Be a Scientist! will be successful with the engineers if we measure >60% gains in communication skills and community awareness.

BE A SCIENTIST!'S STRATEGIC IMPACT ON ISE

The project will impact ISE by: 1) creating sustained learning experiences that help ISE organizations broaden participation; 2) fostering collaborations between universities and ISE organizations that bring current research to the public; 3) impacting the STEM pipeline by bringing social capital to underserved communities; 4) developing and implementing technology-based, data-driven, evaluation and resource-allocation tools; 5) identifying factors that develop persistent participant interest in STEM; 6) developing a PLP that will empower parents co-invest in and sustain the program in their community.

RELATED WORK

We draw from the following to develop a powerful program for our diverse stakeholders:

Broadening participation: There are many models of involving diverse audiences in ISE. Some models include the 2000 conference, "The Challenges and Impact of Human Genome Research for Minority Communities" that allowed minority communities to share their thoughts on genomics. Another example is the Science Museum's Dana Centre, London, which conducts programs on science, technology and culture that are co-created by the Dana Centre and Chinese and Afro-Caribbean communities [63].

Public engagement and understanding of science: The NSF-funded Portal to the Public Initiative develops and tests program models that engage scientists and public audiences in face-to-face interactions that promote appreciation and understanding of current science research [64].

Professional development for scientists: BA Perspectives (coordinated by the British Association for the Advancement of Science) encourages scientists, engineers and social scientists to explore the social and implications of their research and trains them to interact with the public at a poster session in a science festival. Another example is the website, "Communicating Science: Tools for Scientists and Engineers" created by the NSF and the American Association for the Advancement of Science to help scientists and engineers communicate better with the public. The website offers webinars, how-to tips for media interviews, strategies for identifying public outreach opportunities, and workshops for scientists and engineers who are interested in learning more about science communication [63].

Cyber learning: Ice Stories (an Exploratorium project) connects citizens to scientists using the Web. The project encourages researchers to blog and webcast their research in Antarctica. It also encourages readers to comment and discuss the posts with the scientists.

Parent Leadership Programs: Much research shows that parents support their child's education more readily when they feel empowered [65, 66]. Key factors that enable sustained parental involvement are: 1) incorporating parent feedback into the program design; 2) providing continued support post-training and gradually reducing the support over 3-4 years.

Family Science: Examples of Family Science programs include the EQUALS Family Science Program [67], the Australian Family Science Project [68], 4-H [69] and the Hands-On Science Outreach program [70]. Others such as the Open Classroom [30, 31] and NSF's Out of School Science Experiences [34] have structured learning experiences that families undertake in formal and informal settings. These family-based programs have been shown to be particularly important in boosting the achievement of underserved students [71-73].

TEAM'S PRIOR WORK WITH FSWS, ENGINEERS AND SCALE-UP

Since 2006, 200 engineers have been trained to conduct 132 workshops reaching ~4000 underserved children and parents at 76 sites in three cities. Main areas of impact have been:

Families: We have provided 15,260 student contact hours and 1400 parent contact hours. We have had ~20-30 families (~40-70 participants) and >85% participant retention for every FSW. We have conducted pre and post tests in each of the 124 workshops and have observed >80% gains in interest, motivation, knowledge of facts and terminology and >40% gains in understanding the processes of modeling and testing. We have developed ways of successfully recruiting and engaging non-English speaking parents. We have also conducted two large parent surveys (n = 361, 943) and one in-depth interview study (n = 9) determining the needs of parents and the impact of the FSWs. Results can be found in Supplementary Documents.

Engineers: We have developed a 16 week training program that enables engineers to communicate complex ideas to the public. 160 engineers and 40 student-engineers have gone through our training and developed curricula on 14 topics. We have developed an engineer evaluation that measures changes in communication, leadership skills and cultural awareness. Through interviews with six engineers and surveys with 12, we have seen that engineers dedicate significant time and effort to the FSWs because of the opportunity to communicate current STEM research to an underserved public and to impact the STEM pipeline.

Scalable model: We have documented key aspects of the program for scaling. We have a detailed engineer training syllabus, lesson planning template, engineer observation forms, detailed guidelines and checklists for engineers, volunteers, translators, parents, teachers and school administrators. We have developed a visualization tool, Urban School Needs (USN) Map that enables us to choose partner schools and allocate resources in a data-driven and cost-efficient manner. We have adapted the model for scalability by conducting seven workshops in the Bay area in 2007 and 2008 and one FSW in Salinas with the Monterey Bay Aquarium in 2009.

BUILDING ON TEAM'S RESEARCH

The *New York Hall of Science* is the City's only hands-on science and technology center and host to nearly a half-million visitors every year. NYSCI serves the most ethnically diverse population in the country and has much experience in attracting and retaining families from local communities for STEM programs. NYSCI has a proven, decade long, after-school science program that attracts and retains 150 local K-8 students year after year. NYSCI has developed a social networking site to connect these students and their parents to build a community and share resources. The after-school students feed NYSCI's signature program, the Science Career Ladder program, where ~200 high school and college students, called Explainers, engage visitors in science conversations based on exhibits. A 2009 evaluation showed that over 60% of these students from underrepresented communities go on to careers in science and education.

The *Natural History Museum* hosts one of the most economically and ethnically diverse audiences of any museum in Los Angeles. Most of last year's ~ 200,000 students who visited the Museum were from LAUSD, where the need for increased STEM opportunities is critical.

Prof. Cumberbatch has led teams of undergraduates to West Africa for the past six years to pursue research projects addressing the energy, water and shelter. These projects have resulted in water filters, solar lighting systems and sustainable designs for mud buildings.

Prof. Narayanan's Signal Analysis and Interpretation Laboratory has been developing advanced audio-visual data acquisition and analysis technologies (supported by NSF, NIH, DARPA, ONR and the Army) for identifying, tracking and analyzing voice, language and emotions [74-76]. Recent projects include creation of two-way translation technologies to bridge language and cultural gaps and automated observational coding (based on audio-visual data) for modeling social interaction and communication in domains such as Autism [77].

Prof. Mayer has received USAID support to implement communication campaigns on girls' education in Zambia, increasing parental participation in Lesotho and slowing down cholera transmission in Suriname. She has provided workshops and design expertise to enhance these programs and is currently on the Scientific Advisory Board for "Transforming Cancer Knowledge, Attitudes and Behavior through Narrative" that is funded by NIH.

Iridescent has been funded by the National Heart, Lung And Blood Institute for "Disseminating Scientific Information on Autism to the Latino Community". Iridescent will train Biomedical engineering graduate students to share current Autism research with the Latino community.

Prof. Narayanan and Ms. Chklovski were also recently awarded the Fund for Innovative Undergraduate Teaching, USC to develop innovative, low-cost, learner-directed experiments that bring current Electrical Engineering and Computer Science research to the public.

RELEVANT PRIOR NSF SUPPORT

Dr. Gupta has led numerous federal projects with both local and national impact. Through a recently-completed ITEST program, "Crime Scene Information Technology", Dr. Gupta's team developed technology-rich, forensic science mystery activities for urban classrooms that promoted student-centered learning, critical thinking and problem solving. Dr. Gupta recently won another ITEST grant for the "Virtual Hall of Science" through which middle and high school students will develop STEM interactives in a virtual world for field trip visitors.

Prof. Cumberbatch was awarded a three year NSF OISE grant for "Lessons from Africa: Undergraduate Engineering Research in Rural Ghana" in which students worked in remote rural regions learning about true holistic sustainability at first hand.

Prof. Narayanan has led many NSF-funded projects that will support the proposed research. His CAREER grant (2002–2008), *Modeling and Optimizing User-Centric Mixed-Initiative Spoken Dialog Systems* resulted in over 75 publications. The user sensing (including aspects of engagement, interest, boredom and frustration) and modeling aspects of this project will inform the proposed audio-visual data based evaluation. Narayanan was PI on a NSF IERI project (2003–2009), *Automating Early Assessment of Academic Standards for Very Young Native and Non-Native Speakers of American English*. The project led to over 30 papers and a system prototype that was tested in Los Angeles schools. The automated speech interaction based assessment using Bayesian methods will be useful in some of the automated coding. Additionally, Narayanan has been a co-PI and a research director for an NSF ERC on *Integrated Media Systems* where he led integration projects on human centered communication systems including the creation of SmartRoom environments for audio-visual data gathering and automated interpretation especially in group settings. Narayanan is also PI or co-PI on several other NSF supported efforts, focusing on human-centered communication and robust intelligent technologies.

Iridescent is collaborating with a California State University-Fresno team working on "MRI:

Acquisition of a High-speed Camera System to Record Animal Movements in Three Dimensions" (NSF#0821820) develop a FSW on motor neurons.

B. PROJECT DESIGN

Be a Scientist! will conduct 76, five-session FSWs in five years, directly providing 10 contact hours each to 1170 participants in New York City and 50 contact hours to 600 participants in Los Angeles (Figure 1). We will conduct interviews and surveys with families and engineers and incorporate feedback systems through FSW evaluations and online forums on a parent social networking Ning site so that the project addresses stakeholder's concerns and needs.

SUPPORT:
1. Overall: Iridescent
2. STEM: USC & Cooper Union
3. ISE: NYHS, NHM
4. Evaluation: EDC / CCT

ADVISORY BOARD:
1. Communication: Dr. Ernest Wilson
2. Psychology: Dr. Robert Rueda
3. Family Science: Dr. Angela Calabrese Barton
4. Scale-Up: Dr. Christopher Dede
5. ISE: Dr. Leah Melber
6. Industry Support: Dr. Marcus Mitchell

	PEOPLE	ACTIVITIES	DELIVERABLES	MILESTONES
	Iridescent	Develop Ning Site	Ning Site	Fall 2010
		Add Additional Indicators	USN Map Project (LA)	Fall 2010
		Develop NYC Database	USN Map Project (NYC)	Spring 2011
		Work with Engineers	5 T-shirts	1 / Year
People Being Recruited & Trained	140 Engineers (LA, NYC)	76 Family Science Workshops	640 hours of STEM+ISE Training	2 Training Programs / Year
	50 Translators (LA) 150 Explainers (NYC)		30 hours of STEM Training	
	690 Families (LA, NYC)		50 Hrs to 300 Families (LA) 10 Hrs to 90 Families (NYC)	
	50 Parents (LA)	Parent Leadership Program	50 Hrs Leadership + Ning Orientation	2 Training Programs / Year, from Spring 2011
	USC Cinema Students (LA)	Use Participant-Generated Footage	10 Videos	2 / Year
	Electrical Engineering Graduate Student	Audio-Visual Evaluation Research	Feasibility Recommendation	1 Publication / Year

OUTCOMES for 3 Main Recipients: ENGINEERS = 60% Gain in Communication; FAMILIES = 80% Gain in Knowledge & Interest; PARENTS = Increase in Collective Efficacy

Figure 1 Five year project components, stakeholders, activities, research, deliverables, milestones and supports.

Research effects of scale-up and technology-based evaluations

Be a Scientist! presents a scale-up challenge of magnitude, breadth and programmatic complexity [78]. The model has gone through three stages that will enable it to *scale successfully*: 1) We have shown it to be effective – i.e. we have credible evidence that the innovation has measurable and desirable effects; 2) We have shown that the initial successes can be replicated in settings similar to those in the scale-up site; 3) There is an established institutional mechanism (the nonprofit, Iridescent, partnering with universities and ISE organizations) to accomplish the scale-up. We will gather and disseminate data on the following:

Impact of experience: Does program effectiveness increase as stakeholders increase experience?

Impact of scale: Is there a difference in effectiveness when comparing small-scale treatments (i.e. workshops in one city) with large-scale treatments (i.e. workshops in two cities)?

Fidelity of implementation: Does the degree to which the program is implemented as intended by its authors affect program outcomes?

Feasibility of audio-visual evaluation: Can we use automated audio-visual evaluations as a cost-effective, scalable way of measuring participant interest and instructor effectiveness?

The PIs will develop formative and summative evaluations that will be given to FSW participants at both sites to address the above questions. The PIs will continue using the current methods for gathering data through observations, interviews and surveys of children, parents, ISE experts, engineers and K-12 educators. Program effectiveness at each site will be measured by the success in achieving the desired learning outcomes.

Adaptation to New York City

The New York City FSWs will incorporate the main elements of the original program in Los Angeles. Key differences will be: 1) the FSWs will be conducted at NYSCI instead of at school sites like in Los Angeles; 2) four NYSCI Explainers will help the engineers at each session to communicate with non-English speaking adults; 3) workshop topics will have a specific STEM focus so that we can leverage The Cooper Union's expertise in sustainable engineering.

Innovations in training, community co-investing & media

To address the project's goals, we will implement the following innovations to the model:

ISE-Engineering Co-Teaching Model: Using the co-teaching model [79], engineers and ISE staff will share their expertise and work "at the elbow of one another" to co-generate effective practices. ISE staff will gain insight into science communication and into the culture and motivation of engineers and universities. Engineers will develop a deeper appreciation of free-choice learning and ISE's role in increasing the public's understanding of science.

Parent Co-Investing: We will work with parents to co-invest in the FSWs so that instead of being passive recipients of a charity, they will be a vital force driving the program. We will provide leadership classes for the parents that will help them organize aspects of the FSWs such as food, materials, photo/video documentation of the sessions and recruitment of other families. We have successfully piloted co-investing in 30% of our Los Angeles schools. We have also conducted a Needs Assessment Survey in which 51% of 824 parents expressed interest in co-investing in the FSWs. More details are in Supplementary Documents.

Science T-shirts: Engineers will work with the families to design T-shirts that visualize FSW concepts. So far we have developed designs on fluid dynamics, MRI and electricity. The fluid dynamics design cleared the semi-finals for the 2009 NSF International Science & Engineering Visualization Challenge. The T-shirts have helped increase program visibility, recruit more families, support the families' feeling of pride in their learning and reinforce the FSW concepts.

Social Networking site for Parents: We will use Ning (www.ning.com) to develop a social networking site for parents. The site will provide access to new learning opportunities and create a long-term community of diverse learners and experts interacting together. Based on the results of the Needs Assessment Survey that we conducted, the site will feature short science videos, easy access to engineers, the ability to upload and share blogs, photos, videos or ideas and resources on higher education and STEM careers. The site will also enable us to cost-effectively develop a database of participants and conduct longitudinal evaluations.

Participant-generated Videos: Research has shown that social cues in a multimedia message can prime the social conversation schema in learners. Once learners interpret their interaction with a computer as social, the rules of human communication come into play and they engage in deeper cognitive processing [80-82]. Based on these findings, we will develop short videos that feature engineers explaining and giving directions, families experimenting and the reflection discussion that will prompt the viewer to answer conceptual questions [83]. USC School of Cinematic Arts students will use material shot by the families and cut and finish 2-4 minute videos. The videos will be posted on the Ning site and will help families reinforce the concepts and enable them to replicate the experiments at home.

IMPLEMENTATION PLAN

Main project implementation activities include recruiting and training the engineers, translators and Explainers and implementation of the FSWs in the fall and spring of each year (Figure 1).

RECRUITMENT OF SITES, ENGINEERS, TRANSLATORS & FAMILIES

Los Angeles Sites: We have developed the USN Map that helps us compare Los Angeles public schools based on publicly available data. Thus we can make more data-driven decisions, scale cost-efficiently and identify long-term school partners that need and want to co-invest in the FSWs. Degree of need is measured by parent income and education levels, school crime and Academic Performance Index. Ability to support the FSWs is measured by parent response and administration's efficiency (e.g. the time taken to repair computers). We propose to add New York City school data and use the map to identify new partner schools as we scale. The map can be accessed from www.IridescentLearning.org, About Us, Impact, USN Map Project.

Engineering undergraduates at USC and The Cooper Union will enroll in "Engineers as Teachers" and receive three units of technical elective credit for implementing the FSWs. Every semester we will recruit undergraduates by presenting in different classes, conducting social events and design competitions. We will maintain a database of volunteers, alumni and potential candidates and send out a monthly newsletter. We will encourage applications from women and minorities by advertising through campus diversity organizations. Undergraduates will be paired with volunteering graduate students or professional engineers. We will recruit the volunteers using Idealist.org and VolunteerMatch.org. We have recruited 20 undergraduates and 20 volunteers every year through these methods.

Interested candidates will go through a *rigorous screening* process. They will: 1) provide a statement explaining why they are suited to this project. This stage will test applicants' interest, ability to self-analyze and write; 2) present a five-minute lesson on a topic of their choice. This will test their comfort with public speaking, preparation, time management, and initiative.

Translators: We will recruit translators through Idealist.org and Volunteermatch.org. Interested candidates will be asked to commit four hours/week for five weeks and will go through an interview screening process before being matched with the engineers.

Families: In Los Angeles we will work with partner schools and recruit families by showing videos from previous FSWs at Back to School Nights and parent meetings and by sending invitation letters to the parents. In New York City we will use NYSCI's existing systems and recruit through their >7000 membership database Queens and Brooklyn residents, advertising to the 150 after-school program students and through their 25 active local school partnerships.

TRAINING ENGINEERS, TRANSLATORS & EXPLAINERS

Engineers: At both sites engineers will go through 16 weeks of training during which they will teach two FSWs. Training will be conducted by The Cooper Union, Iridescent, NYSCI and NHM and will address: how people learn, audience types and motivations, strategies for working with various age groups and designing engaging multi-media experiences [84]. The training will also give engineers a model for effective direct instruction, opportunities for them to practice their new skills and ways for them to self-evaluate their teaching.

Specifically, engineers will be given a lesson plan template that helps them break down complex ideas into simple lessons, identify learning objectives, design aligned, learner-directed experiments and assess learning. Two well established lesson plan approaches will be utilized: the Learning Cycles lesson approach [85] and Inquiry-based instruction [86]. Engineers will practice teaching using few technical terms, real-world analogies and multi-media to ensure understanding for diverse audiences with limited education. Engineers will also learn to use graphic organizers and other assessment practices to ensure families make significant knowledge gains [87]. Weekly preparation will include a reading assignment, instructional planning, lesson study, and reflective practice. During FSW sessions, each engineer will be observed bimonthly by Iridescent or ISE staff. Engineers will videotape each other and share the videos with the project team.

ISE Training: Training sessions will be attended by NYSCI and NHM staff. ISE experts will co-create and co-teach with the engineers to ensure the FSWs have the essential elements of free-choice learning. In addition there will be two training sessions focusing specifically on ISE.

Training details by week and the lesson plan template that engineers will use to develop their lessons are given in Supplementary Documents.

Explainers and Translators will be given scripted lesson plans beforehand and will spend one session with the engineers going over the concepts and experiments so that they can accurately translate the instruction.

FAMILY SCIENCE WORKSHOP IMPLEMENTATION

Los Angeles: We will partner with ten elementary schools and conduct ten FSWs every year. We will start with 1st grade students and work with them for five years to measure longitudinal impact of the program. Each FSW will consist of five evening sessions of two hours each. Families will be invited (including younger siblings). Formative assessments such as Exit Slips (three questions checking for content understanding) will be conducted at the end of every session. Pre and post tests will be conducted in each FSW. Food will be provided at every session. In Los Angeles, instruction will be translated into Spanish if the majority of families are Hispanic and non-English speaking. FSWs that align with the NHM exhibits (such as Animal Locomotion, Structural Color and Bird Flight Aerodynamics) will be held at the museum, while the rest would be held at the schools.

New York City: NYSCI will conduct two FSWs on Sustainability in year 1, four in years 2 and 3 and eight in years 4 and 5. Workshop format will be the same as that in Los Angeles. Engineers will partner with a NYSCI staff member and co-lead the workshops. Four Explainers will facilitate communication between the audience and the instructors.

PARENT LEADERSHIP PROGRAM & NING ORIENTATION CLASSES IN LOS ANGELES

After conducting the first FSW at each of the schools we will offer parent leadership and Ning orientation classes once a year to interested parents. We will elicit parents' suggestions and needs through surveys and interviews and design the program to directly address them.

Audio-visual processing & automated data interpretation research

Observational human behavior analysis across a variety of applications such as analysis of meetings and focus groups relies on audio and/or video for identifying micro- and macro-level behaviors of individuals and the dynamics between the interacting participants. Such data are used to provide objective information to support assessment and intervention design, and supplement instruments such as surveys and self reports. For example it can be used to measure how engaged an individual was on a task by measuring time on task and other cues of positive/negative behavior through vocal and language cues. Audio-visual processing and automated data interpretation can aid behavior based research and practice by providing a rich transcription and help reduce human coding efforts. For example, audio and video data of an individual can be localized and tracked automatically to yield task-based statistics. We will collect and analyze detailed, rich human interaction data in a cheaper and faster way, and facilitate new types of longitudinal and fine grained analyses of interactions (such as tracking the dynamics of emotional activation/valence during the course of an interaction). Our models of both an individual's data and of inter-participant dynamics will place raw information into situational context and cross-reference it with relevant domain knowledge. We do not intend to supplant the knowledge of the expert, neither remove the raw information streams, but instead supplement with meta-feature streams based on machine reasoning of the raw observations.

STEM, ISE and infrastructure deliverables

STEM deliverables include a replicable, well-documented engineer training program that will be implemented in two universities – USC and The Cooper Union. In addition we will develop curriculum for 20 physics-based workshops with complete documentation that includes five lesson plans, pre and post assessments, Exit slips and multi-media resources. Media deliverables include a social-networking website for parents, ten short videos and five science T-shirt designs. We will deliver 640 hours of STEM communication and ISE training to 140 student engineers, 50 FSWs in Los Angeles reaching 600 participants and 26 FSWs in New York City reaching 1170 participants. We will implement and evaluate a Parent Leadership Program. We will research the feasibility of using automated, audio-visual evaluation in the FSWs. Finally we will deliver the USN Map, a visual resource allocation tool that will enable informal science education organizations to become more data-driven and cost-effective in choosing long-term partner schools and communities that will be able to co-invest in the programs.

Be a Scientist!'s learning outcomes for families, engineers and ISE

Outcomes for the families include developing the motivation to learn about science and to think of themselves as science learners [63]. Ongoing involvement will lead to positive changes in communication at the individual, family and community levels. Measurable outcomes include an 80% increase in families' STEM knowledge, interest and collective efficacy. Outcomes for the engineers include >60% gains (measured through self-reports and external evaluations) in: 1) awareness of their strengths and weaknesses while interacting with the public; 2) understanding motivations and learning styles of diverse audiences; 3) communication skills with the public. In addition engineers may think about their work in terms of its larger social implications. Lastly we will address *Challenge 1* by gathering and disseminating data on scaling an ISE program in underserved communities and by conducting technology based evaluations.

External evaluation

The three-stage evaluation will use a multi-method research approach to inform project implementation. The evaluation will be conducted by Dr. Harouna Ba from the Education Development Center's Center for Children and Technology (CCT). CCT will investigate the project's impact on families' STEM learning and effectiveness in achieving broader dissemination compared with the original program. Data will be gathered using surveys, interviews, pre- and post-test scores, concept mapping, and fieldwork [88-94].

The evaluation will be based on the following questions: 1) Are activities such as recruitment, training and FSWs aligned with the project's goals? 2) What is the impact on families' interest in and understanding of science? What is the impact on engineers' communication skills and perspectives about their work? 3) Is the project scalable, able to produce effective technology assessment tools and develop long-term partnerships with schools?

Stage 1: Project staff, stakeholders and researchers will use a logic model process to ensure buy-in from all stakeholders, development of sensitive evaluation tools and alignment of all projects inputs and activities with short and long-term outcomes [95, 96].

We will collect baseline data about the existing project's outputs, participating families (e.g., education levels, language, availability, science knowledge and practices), and engineers (e.g., communication abilities). Pre-assessments about families' STEM experience and knowledge, social capital and interest and engineers' public communication skills will be administered.

Stage 2: CCT will conduct formative evaluations over the first four years. CCT will document the quality of recruiting, training, ISE co-teaching, curriculum development, FSW and PLP implementation. CCT will design sensitive research instruments (e.g., interviews, observations, surveys) and conduct site visits. CCT will deliver formative research summaries that share findings and recommendations with project staff to better meet the needs of target audiences.

Stage 3: CCT will conduct a summative evaluation in the last year. CCT will determine how well the project met its goals of improving families' understanding of science, parental involvement in their children's education, social networking with experts, longitudinal impact and scalability. CCT will develop and administer pre- and post-tests for core activities to measure change in participants' understanding and behaviors. CCT will examine how multiple contextual factors such as socio-economic factors, quality and accessibility of experts and educational and technology resources, affect participants' interaction with the curriculum and activities. This summative phase will culminate in the delivery of a final research report.

DISSEMINATION TO UNDERSERVED AUDIENCES, ISE & ENGINEERING VENUES

Project findings and materials will be disseminated to the following audiences:

Underserved Audience: We will present FSW videos at school events every year. We will work with New America Media (the country's first and largest national collaboration of 2000 ethnic news organizations) to disseminate our videos. Based on recommendations from the Needs Assessment Survey we conducted in Fall 2009 (more details of which are given in Supplementary Documents) we will burn the science videos onto DVDs and give them to 2000 families each year. Learning from the NSF-funded, "Science and Math in Spanish-language Media" we will host booths at community festivals and events at libraries, and community centers. The science T-shirts will also help increase project visibility.

ISE Venues: We will present at ISE conferences and submit to journals such as the International Journal of Science Education, Journal of Museum Education, Journal of Research in Science Teaching and Science Education. We will submit conference sessions to the annual conference of Association of Science and Technology Centers (ASTC). We will submit 2000 word articles to the Center for Advancement of Informal Science Education newsletters and ASTC Dimensions. Finally we will share project findings through www.informalscience.org and ISE blogs.

Engineering Venues: We will post STEM curricular analogies on our existing "Analogies for Teaching Science" wiki. We will submit papers to the American Society for Engineering Education, journal articles to the Journal for Engineering Education and articles to societies such as the American Society of Mechanical Engineers and the Optical Society of America and minority organizations such as the Society for Hispanic Professional Engineers and National Society of Black Engineers. Other dissemination venues will include STEM, engineering education and science communication blogs. We will share best practices and videos with the Center for Excellence in Teaching, USC and through similar venues at The Cooper Union.

Results from the novel audio-visual evaluation research will be presented in peer reviewed engineering venues such as IEEE Transactions and conferences in Multimedia and Signal Processing as well as the assessment instruments in the Journals for Engineering Education.

General Project Dissemination: We will regularly post FSW videos on Iridescent's YouTube channel. Co-PIs will update their organizations' websites and blogs. We will publish STEM and ISE articles in the National Science Teachers' Association journals. Other venues will include sharing the t-shirt designs with science-art and graphic design blogs and FSW curriculum and videos with parent and teacher blogs and forums. We will contact urban science education panels through which we could share project findings. Lastly, we will share the USN Map with urban education nonprofits and information visualization groups and blogs.

SUSTAINABILITY THROUGH CO-INVESTING PARENTS & PARTNERS

Post award Iridescent will support the growth trajectory of the partnerships formed between the universities, museums and parents. NYSCI and NHM will institutionalize the FSWs and offer them to all visitors. The universities will build the "Engineers as Teachers" course into their budget. USC will provide significant financial support ($85,000) for five years post-award. The PLP will empower parents to take ownership of and co-invest in the FSWs.

After the program has scaled and the infrastructure established, the cost of one FSW is ~$2500. Partnering universities will cover 13% of costs enabling recruiting and training of the engineers. Iridescent will cover 34% of costs covering observing the engineers, recruiting the schools and families and running the PLP. ISE partners will cover 26% of the costs that would include insurance, dissemination and printing. Food and materials (27%) will be covered by the parents.

C. PROJECT MANAGEMENT

The project enables inter-disciplinary collaborations between the scientific research community, ISE professionals and the public. The Computer Science and Electrical Engineering departments at USC will support incorporation of technology into the existing model to make it more scalable. Engineering schools at USC and The Cooper Union will provide engineers and access to university-based research. NYSCI and NHM will provide ISE expertise. The USC School of Cinematic Arts will help harness media to increase public engagement with science. Finally, Iridescent will provide the necessary prior experience in recruiting and training engineers, conducting FSWs with underserved communities and scaling the program to a new site.

TEAM MEMBERS

PI - Tara Chklovski, Founder, CEO, Iridescent: Ms. Chklovski brings STEM content knowledge and executive administration abilities to the effort. She has previously worked as the principal at a 300 student K-6 school in India. She has consistently and cost-effectively doubled Iridescent's impact every year by heavily relying on technology, synergistic partnerships, rigorous evaluation and volunteers. She brings extensive knowledge of involving underserved communities in STEM, training and supporting engineers and mobilizing hundreds of volunteers to unite and accomplish big projects. Under her leadership the project will implement innovative, technology-based improvements to the Family Science model. As PI she will coordinate and direct the overall effort.

Co-PI – Prof. Shrikanth Narayanan, Electrical engineering, Computer Science, Linguistics, Philosophy, USC: Prof. Narayanan is an internationally recognized expert in human-centered information processing and communication technologies with over 350 papers and 7 granted patents. He is an active mentor to undergraduate and graduate students in interdisciplinary engineering research and has extensive experience with K-12 outreach. He will provide the link to USC's Viterbi School of Engineering through which the Los Angeles site will recruit engineering undergraduate and graduate students. He will also advise the graduate student conducting research on automated analysis of FSW videos.

Co-PI – Preeti Gupta, Senior Vice President of Education and Public Programs, New York Hall of Science: Dr. Gupta brings her expertise in ISE programs to the project. At NYSCI, she is responsible for all K-12 student programs, after-school programs, interpretation staff, annual professional development for ~ 3000 teachers, Digital Learning Programs, Science Technology Library and Public Programs including sleepovers and early childhood initiatives. She will coordinate the NYSCI effort.

Co-PI – Prof. Doe Mayer, Mary Pickford Chair, USC School of Cinematic Arts: Prof. Mayer teaches documentary and fiction filmmaking and has been working in film and television for the past 25 years. She has produced, directed and provided technical support for hundreds of productions, many in basic education and women's issues in the United States and developing countries. She will advise Cinema school students in developing the ten short science videos.

Co-PI – Prof. Toby Cumberbatch, Electrical Engineering, The Cooper Union: Prof. Cumberbatch founded the Center for Sustainable Engineering, Art and Architecture – Materials, Manufacturing and Minimalism and has successfully implemented a Sustainable Engineering and Development course that culminates in a final project presenting a real problem to be solved in Ghana, Kenya or Rwanda. He will adapt and implement the "Engineers as Teachers" training program to suit The Cooper Union students.

Molly Porter, School Programs Manager, Natural History Museum, Los Angeles: Ms. Porter has been developing informal, interdisciplinary science programs for the past five years at multiple Los Angeles museums. At NHM, she oversees all school programs serving ~125,000 school children/year. She will provide the relevant ISE experience, conduct informal education training for the engineers and coordinate all activities hosted by the NHM.

Lindsey Jenkins-Stark, Vice President Operations, Iridescent: Ms. Jenkins-Stark was a Teach for America Math/Science teacher and brings inquiry-based teaching experience and knowledge of urban, minority communities. She was a member of a LAUSD decision-making committee and a lead teacher. As part of the Be a Scientist! senior team, she will recruit schools, engineers and families, train the engineers, coordinate the PLP and conduct the FSWs in Los Angeles.

Luz Rivas, New York City Site Director, Iridescent: Ms. Rivas brings ISE experience and a record of managing STEM programs for underrepresented youth. She worked at the American Museum of Natural History and developed models for STEM after-school programs and has experience training after-school science instructors. She will assist Prof. Cumberbatch in recruiting and training engineers and will work with NYSCI to ensure smooth implementation of the FSWs.

External Evaluator - Dr. Harouna Ba, Center for Children & Technology: Dr. Ba has extensive experience in children's development of digital literacy skills, and evaluation of multimedia programs in formal and informal settings. He has also investigated the relationship between underserved communities and technology.

ADVISORY BOARD

Prof. Robert Rueda, Professor, Psychology of Education, Rossier School of Education, USC. Prof. Rueda's research has centered on motivation, learning, and instruction. He recently served as a panel member on the National Academy of Science Report on the Overrepresentation of Minority Students in Special Education. He is a fellow of the American Psychological Association, the American Educational Research Association, and recently served as the associate editor of the American Educational Research Journal.

Prof. Ernest James Wilson III, Dean of the Annenberg School for Communication, USC. Dean Wilson's experience in communication and public policy spans the private and public sectors. He was elected the first African-American chairman of the Corporation for Public Broadcasting in September 2009. He has been a consultant to the World Bank and the United Nations and has worked at the White House National Security Council.

Prof. Angela Calabrese Barton, Professor, College of Education, Michigan State University. Her research focuses on equity in urban science education. Drawing from qualitative and critical/feminist methodologies, she conducts ethnographic and case study research that targets the science teaching-learning experiences of upper elementary and middle school youth and parents engaging in their children's science education.

Prof. Christopher Dede, Harvard Graduate School of Education. Prof. Dede's interest is in the expanded human capabilities for knowledge creation, sharing, and mastery that emerging technologies enable. His research spans emerging technologies for learning, infusing technology into large-scale educational improvement initiatives and leadership in educational innovation.

Dr. Leah Melber, Director of Student and Teacher Programs, Lincoln Park Zoo, Chicago. Dr. Melber brings extensive expertise in family learning in museums as well as effective connections between formal and informal education. Her research has been shared through numerous peer reviewed publications and national and international presentations.

COLLABORATION PROCESS

We will use an online project management website, Basecamp (www.basecamphq.com) to coordinate activities. We have successfully used Basecamp for the past three years to coordinate ~250 people on 32 projects. We will employ bimonthly teleconferencing and net meetings to allow direct, real time collaboration on documents and planning. Informal dinners will also be held for engineers, project team members and other stakeholders so that everyone feels part of a powerful program and shares a sense of purpose and achievement.

FIVE-YEAR WORK PLAN

We will recruit and train engineers at both sites every semester for 16 weeks. We will conduct 10 FSWs every year in Los Angeles, two in year 1 at NYSCI, four in years 2 and 3 and eight in years 4 and 5. We will develop the Parent Leadership Program and Ning site in Fall 2010 and offer supporting classes twice a year from Spring 2011(Figure 1). We will add two videos and curriculum for four FSW topics every year to the Ning site and update the blog, photos and videos every month. We will add additional USN Map indicators for Los Angeles in Fall 2010 and for New York City schools in Spring 2011. Post award the FSWs will be collaboratively sustained by Iridescent, USC, The Cooper Union, NYSCI, the NHM and co-investing parents.

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