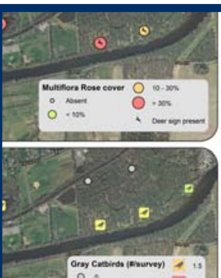
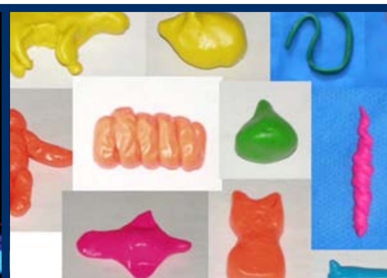
A SPECIAL TRIBUTE
ISSUE TO
ALAN FRIEDMAN

SCIENCE EDUCATION & CIVIC ENGAGEMENT

AN INTERNATIONAL JOURNAL





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Alan J. Friedman

Throughout his distinguished career, Alan J. Friedman had a strong commitment to making science and technology more appealing and understandable to all. He received a bachelor's degree from the Georgia Institute of Technology and held a Ph.D. in Physics from Florida State University, while also studying literature along the way. He spent most of his professional life as a museum educator. He developed science education projects for children, teachers, adults and family audiences at UC-Berkeley's Lawrence Hall of Science, served as a senior planning consultant at the Conseiller Scientifique et Muséologique, Cité des Sciences et de l'Industrie for a new national museum located in Paris, and was director of the New York Hall of Science for 22 years, where he revitalized the moribund institution through creating interactive exhibits and educational programs, including a Science Playground, a Rocket Park, and a science career program for high school and college students that helps them relate science to the issues of their own communities.

Dr. Friedman was the inspiration for and founding director of SENCER-ISE (Science Education for New Civic Responsibilities and Engagement – Informal Science Education), an initiative of the National Center for Science and Civic Engagement, to encourage cross-sector partnerships between higher education and informal science education institutions.

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Publisher's Note

What's the worst part about death? This is a tough question. As I think about the year since Alan Friedman's untimely passing, I propose an answer.

Thanks to tributes and reflections made after his death, his obituary in the *New York Times*, and from the articles contained in this special issue, I now know things about Alan that I never knew before.

Of course, I know these things only in part, to be sure. Had I had even an inkling of these dimensions of Alan's remarkable life and career, I would have surely pursued them in one of our many conversations. But that can't happen now.

Death is the rudest of interruptions. So what's the worst part? It's the end of what Whitehead called "the great conversation."

An acute case comes to my mind as I write this today.

I always saw Alan as a humanist and scientist, equally at home in the knowledge *(scientia)* fields and what I call the wisdom fields. Alan was deeply and broadly read, an aesthete, you might say, if that word had not been so badly contorted. And Alan's interests embraced all kinds of art, from literature to film.

While he and I had occasionally talked about Alan's experiences of working with (and under) a collection of New York's mayors, the two of us never discussed Alan's courageous and critical role in the struggle involving art and freedom. It was only after his death that I learned of Alan's role in the 1999 dustup between Mayor Guiliani and the Brooklyn Museum.

Mayor Guiliani had threatened to cut funding to the museum over its display of art that he, as mayor, deemed offensive. I remember the incident and how ironic it seemed to me to be. After all, the mayor was a devotee, indeed a champion, of opera. I love opera myself. But if you don't want to be exposed to drama laced with sacrilege, treachery, incest, brutality, and all manner of mayhem, you should probably avoid opera. The Mayor, I recall thinking at the time, seemed strangely selective in his choice of things to find offensive.

Alan Friedman

What was the cause for the Mayor's concern? Abby Goodnough, in the *Times*, wrote the following as a lead for her article:

> "Mayor Rudolph W. Giuliani stepped up his attack on the Brooklyn Museum of Art Thursday, threatening to terminate its lease with the city and possibly even seize control of the museum unless it cancels a British exhibition that features a portrait of the Virgin Mary stained with elephant dung."

In that same piece, Goodnough wrote that "although the directors of many of the city's prominent museums expressed dismay,… most refused to speak publicly about the controversy yesterday." The eminent directors of Metropolitan Museum of Art and the Museum of Modern Art justified their silence by saying that speaking might jeopardize "negotiations" between the mayor and the Brooklyn Museum.

A week and a half later, the *Times* had this headline, "A Scientist Rallies Allies for Besieged Art Museum." Dinita Smith's report begins by telling us that "it took a physicist to galvanize many of New York City's most important cultural institutions to take a stand in the battle over the 'Sensation' show at the Brooklyn Museum of Art."

And that "scientist" was our friend Alan, brave, steady, canny, and effective, as always.

I am left wanting to know more. I wish I had had the chance to ask Alan to tell me this story and to talk with me about what, years away from it, the story could be said to signify.

How much I wish now—especially in the shadows of the shootings and deaths in Copenhagen, Charlie Hebdo, and the "Muhammad Art Exhibit" event at the Curtis Culwell Center in Texas—that I could hear Alan's views on freedom, risk, provocation, and education.

Now that I know about Alan's role in the Sensation show, I understand much better why he was so immediately attracted to the work we got to do together—to put the contested topics of civic consequence at the center of partnerships between the formal and informal education sectors.

But now that I know what I do, I am left wanting to know even more. I miss the chance to learn from Alan, to be with him, to hear his gentle voice, to ask the questions I never got to ask.

This is what grieving is. There is a consolation, of sorts: as I wrote after learning of his death, we can work to put Alan's wisdom into practice. That is what I know we, and so many of Alan's colleagues and friends, are continuing to do.

In that very familiar passage from John 14:2, Jesus tells us: "In my Father's house are many mansions: if it were not so, I would have told you."

So it is with each of us: we are all houses of many mansions, rooms and indeed whole wings of rooms that others can only explore if they ask us for access. We wish we had been given more time for a longer house tour with Alan. We make up for that loss by contributing the parts we each know to make a larger collage of Alan's life.

I want to thank Margaret Honey, our guest editor, Ellen Mappen, and all the contributors for helping to bring this special edition to fruition. And I join you all in thanking Alan for giving us such great material to work with and the inspiration to keep up his good works.

— Wm. David Burns
May 8, 2015

From the Guest Editor

I am honored to introduce the Summer 2015 issue of *Science Education and Civic Engagement: An International Journal*. This special issue will serve as a lasting tribute to Alan J. Friedman and his legacy of advancing science education, both in and out of the classroom. Alan's work at and with different institutions, including the Lawrence Hall of Science, the New York Hall of Science (NYSCI), and the National Center for Science and Civic Engagement (NCSCE), often crossed disciplinary boundaries but always focused on the importance of making learning real and relevant.

In my opening remarks to the "Celebrating the Life and Work of Alan Friedman" [*Thinking of Alan Friedman*] memorial held at NYSCI on Saturday, June 14, 2014, I noted how I turned to Alan for his advice, guidance, wisdom, and expertise after I became President of that institution in 2008. He had retired from NYSCI in 2006, after a wonderful 22 years of service. In my mind, Alan was a larger-than-life legend. What I found when I met Alan was a humble man who exhibited a fundamental humanity in his approach to life and work. He did not realize how much his presence, his passion, and his vision for engaging the public in science would continue to influence what we do day in and day out at NYSCI and throughout the field.

The issue begins with personal memories from Alan's colleagues and is followed by scholarly pieces on a range of informal science education projects and activities, involving engagement by students of all ages in issues of civic importance. Alan was the inspiration and founding director for SENCER-ISE (Science Education for New Civic Engagements and Responsibilities-Informal Science Education), an initiative of NCSCE to encourage learning across the sectors. This issue features three contributions by SENCER-ISE partners.

In the first section, **Ellen Mappen, Sheila Grinell, Eric Siegel, Alan Gould, Wm. David Burns,** and **Priya Mohabir** all speak to the multifaceted contributions Alan made to science education and to other fields. **David Ucko** bridges the gap between this section and the next by looking at how basic tenets of the SENCER framework align with those of informal science education. This section ends with a reprint of "In Memoriam," which **David Burns** wrote on May 5, 2014 to share the sad news of Alan's death with the SENCER community.

Two point of view articles open the next section. **Martin H. Smith, Steven M. Worker, Andrea P. Ambrose**, and **Lynn Schmitt-McQuitty** address the benefits that out-of-school science programming can have on the academic achievement of K–12 students. **Michelle Kortenaar, Allison Sribarra,** and **Tamar Kushnir** discuss a SENCER-ISE project that engages undergraduate students in developing tools for parents and other caregivers to encourage children's scientific exploration.

The issue also features seven project reports, which show the diversity of work in informal science education and the many connections with institutions of higher education. **Jennnifer A. da Rosa, Sarah S. Durkin, Rachel Hetlyn, Mark Murray,** and **Angela Leimkuhler Moran** focus on United States Naval Academy undergraduates who facilitate informal STEM education outreach events for K–12 students and teachers and on the impact of this civic engagement on the Naval Academy students. **Jill Denner, Jacob Martinez, Heather Thiry,** and **Julie Adams** describe an afterschool program that engages Latino elementary school students in computer science concepts. **Amy R. Pearce, Karen L. Yanowitz,** and **Anne Grippo** discuss how their local and campus communities launched a science festival in a rural area. **Flora Ayuluk, James Ayuluk, Susie Friday-Tall, Mary Matchian, Phillip Tulim, Lillian Olson, Lisa Unin, Agatha John Shields, Cathy Coulter, Kathryn Ohle,** and **Irasema Ortega** write about their community engagement partnership that has an overarching goal of sustaining the place, language, and culture of an Alaskan Native village. **Robert E. Pyatt** introduces the concepts behind his informal science outreach workshops called "Weird Science," and discusses some of the challenges he has encountered in his work. **Kathryn Stofer** explores the existence of agriculture-related content in science centers and the potential support around research efforts for global sustainable agricultural production that also could encourage public involvement and action on the issue. **Nellie Tsipoura** and **Jay Farrell Kelly** describe their SENCER-ISE project, in which community college students and citizen scientists work together in a forest conservation effort.

Finally, two research papers provide the results of connections between informal science education and higher education institutions. Linda Fuselier writes about an intergenerational program focusing on the restoration of forest health ecosystems that involves a general education environmental science course, an outdoor education center, and elder participants in a SENCER-ISE project. **Jenifer Perazzo, Carl Pennypacker, David Stronck, Kristin Bass, Jesus Heredia, Rainbow Lobo,** and **Gabriel Ben-Shalom p**rovide results from Afterschool Science and Math Integration (ASAMI), a project that integrates middle school common core mathematics concepts and the Next Generation Science Standards to engage English Language Learners.

I join David Burns in thanking all the contributors to this issue; the articles they have written show the diversity of the field that we know as informal science education and the value of working across sectors to enhance learning, not just by students and the public who visit science centers or view science media but also by educators. This was Alan's goal and his legacy.

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Dr. Margaret Honey joined the New York Hall of Science (NYSCI) as President and CEO in November of 2008. Under her leadership, NYSCI has adopted Design-Make-Play as its signature strategy to promote STEM engagement and learning. The defining characteristics of this sensibility – deep involvement with content, experimentation, exploration, problem solving, collaboration and curiosity – are the very ingredients that develop inspired and passionate STEM learners.

Throughout her career, Dr. Honey has been widely recognized for her work using digital technologies to support children's learning across the disciplines of science, mathematics, engineering and technology. Prior to joining NYSCI, she was vice president of Wireless Generation, an education technology company. Earlier, she spent 15 years as vice president of the Education Development Center (EDC) and director of EDC's Center for Children and Technology. While at EDC, Dr. Honey was the architect and overseer of numerous large-scale projects funded by organizations including the National Science Foundation, the Institute for Education Sciences, The Carnegie Corporation, The Library of Congress, the U.S. Department of Education, and the U.S. Department of Energy. She also co-directed the Northeast and Islands Regional Education Laboratory, a 40 million dollar federally-funded initiative designed to help educators, policymakers and communities improve schools by helping them access and leverage the most current research about learning and K–12 education.

A graduate of Hampshire College with a doctorate in developmental psychology from Columbia University, Margaret Honey has helped to shape the best thinking about learning and technology with special attention to traditionally underserved audiences. She has directed numerous research projects including efforts to identify teaching practices and assessments for 21st century skills, new approaches to teaching computational science in high schools, collaborations with PBS, CPB and some of the nation's largest public television stations, investigations of data-driven decision-making tools and practices, and with colleagues at Bank Street College of Education, she created one of the first internet-based professional development programs in the country. From her early involvement in the award-winning and groundbreaking public television series "The Voyage of the Mimi" to her decade-long collaboration on the education reform team for the Union City (NJ) school district, Margaret Honey has led some of the country's most innovative and successful education efforts.

Dr. Honey has shared what she's learned before Congress, state legislatures and federal panels, and through numerous articles, chapters and books. She currently serves as a board member of National Academies of Sciences, Board on Science Education, and on behalf of the National Research Council, has chaired the consensus study Toward Integrated STEM Education: Developing A Research Agenda, *the workshop report on* IT Fluency and High School Graduation Outcomes, *and co-authored a report on* Learning Science: Computer Games, Simulations, and Education. *Dr. Honey also serves as a member of the National Science Foundation's Education and Human Resources Advisory Committee.*

A TRIBUTE TO ALAN FRIEDMAN

Remembering Alan J. Friedman

Ellen Mappen
May 11, 2015

I am honored but saddened to write a brief introduction to this section that includes remembrances from a number of Alan J. Friedman's colleagues. Alan was the inspiration behind the National Center for Science and Civic Engagement's SENCER-ISE initiative, a project to encourage cross-sector partnerships between informal science and higher education institutions, and was also its founding project director.

Wm. David Burns, in his introduction to this special issue of *Science Education & Civic Engagement: An International Journal* on informal science education, notes that he "saw Alan as a humanist and scientist." Certainly the selections that follow from Alan's colleagues bear witness to the multifaceted nature of his interests, experiences, ideas, and lasting contributions to the field of education, science, and literature and to the impact he had on the lives of the many colleagues who knew him. Alan's interests were wide ranging and included not just a desire to communicate science to the general public, students, and teachers but also to examine cultural influences on science and technology.

In an interview published in these pages in the Summer 2011 issue, Alan described how he came to the field of informal science education. He was a solid-state physicist by training and in 1973 held a visiting professorship at the University of California, Berkeley. He mentioned how he had wandered into the Lawrence Hall of Science, one of the pioneering public science-technology centers. This experience changed his life and he ended up spending twelve years at that institution, primarily as the Director of Astronomy and Physics, with a short leave to serve as the Conseiller Scientifique et Muséologique at the Cité des Sciences et de l'Industrie in Paris from 1982–1984. In 1984, he became director of the New York Hall of Science, a position he held until he retired in 2006. At NYSCI, he revitalized the moribund institution. A description of what he found in 1984 ("zero attendance the year before he arrived") compared with what NYSCI had become by 2006 when he retired can be found on the NYSCI website (http://nysci.org/the-physicist-who-saved-the-hall-of-science/): 447,000 visitors with over 90 full-time staff and 150 high school and college students who served as Explainers in the Science Career

Ladder program, one of Alan's lasting initiatives. In his retirement years, Alan was a Museum Development and Science Communication Consultant and a cherished scholar at the National Center for Science and Civic Engagement.

To open this section, Sheila Grinell shares her memories of Alan's last trip abroad, to Al Khobar, Saudi Arabia, and of her long working relationship with him. In relating her conversation with Alan that took place before their meetings started, she mentions his goal of using SENCER-ISE to bring together educators who have different "institutional perspectives" and also gives us a "Reader's Digest" version of what they discussed. From Eric Siegel, we learn about how Alan always explored the "intersection of science with the arts and humanities" and wanted to understand "the impact of science on society," and we learn much about Alan's intellectual interests and pursuits that ranged well beyond directing a major science center. Alan Gould's brief remembrance highlights how much he learned from Alan Friedman about planetarium presentations and how best to engage audiences in this exciting experience. Priya Mohabir focuses on Alan's contribution to the education of high school and college students and his vision to empower them as science communicators while they themselves learned science. David Ucko's "SENCER Synergies with Informal Learning" gives us an overview of how David Burns and I came to collaborate with Alan in our efforts to work across different educational sectors. David Ucko also provides us with an understanding of the differences between formal and informal learning and his thoughts about SENCER as "a model for synergistically integrating aspects" of these different modes of education. We end this section with a reissuing of "In Memoriam," David Burns' memorial tribute that he wrote on May 5, 2014, the day after Alan's untimely death.

We have lost Alan Friedman and greatly miss his wisdom and friendship. But as Alphonse DeSena, our Program Director in the Division of Research and Learning at the National Science Foundation (NSF), wrote recently,

> Over several decades of service to education and science, Alan Friedman's ideas, actions, and accomplishments were many, insightful, and significant. His contributions in varying capacities to NSF's mission and programs were frequent, critical, and game changing. We at NSF and in the informal science education field cherished him as a colleague, as (in my case) a mentor, and as a friend. His legacy will continue for years to come.

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Ellen F. Mappen is a senior scholar and current director of the SENCER-ISE initiative at the National Center for Science & Civic Engagement. She was the founder and longtime director of the Douglass Project for Rutgers Women in Math, Science, and Engineering at Rutgers University and was the director of Healthcare Services at the New Brunswick Health Sciences Technology High School. In these positions, she has worked to provide opportunities that encourage women and students of color to enter STEM fields. She served as SENCER coordinator for SENCER-ISE. She holds a Ph.D. in history from Rutgers University.

Remembering Alan J. Friedman

Sheila Grinell

I last took a long walk with Alan on February 3, 2014, along the corniche in Al Khobar, Saudi Arabia, where we had gone to teach 18 Saudis how to run science centers. This workshop would be our last joint gig, after 40 years of parallel careers and many shared projects. We had half a day before the workshop was to start, and so we strolled beside the Persian Gulf and chatted.

Not then but in earlier conversations, Alan had told me about SENCER-ISE, and how gratified he was by its progress. He had worked hard to bring together people with differing institutional perspectives, and he was optimistic about the future. No Pollyanna, he knew both sides would have to bend. He said—not in so many words but this is the gist of it—that the universities would have to deal with real people as opposed to an amorphous "general public," and that the science centers would have to up their content game. But there was so much to be gained. He envisioned many more cross-sector projects, and, if he were still with us, he would have inspired collaborations to help them flourish. Everyone at SENCER-ISE knows Alan had the desire, the imagination, and the political acumen to make it happen.

SENCER-ISE was not the first time Alan worked across sectors or disciplines. As an undergraduate he had contemplated majoring in English, but even after physics won out, he continued to relish literature and art. Early in his career, he wrote about connections between science and literature. Later he experimented with theater in the science center: at the New York Hall of Science he commissioned and produced a one-act play dramatizing disagreement between two scientists about quantum mechanics. And for more than 40 years, he delighted in his wife's career as a columnist and mystery writer. Alan was a connoisseur; he could talk eloquently about so many things—and he would go on and on, unless you stopped him. Which brings me back to our conversation beside the sea.

I asked Alan why he hadn't brought one of his beloved radio-controlled helicopters to Saudi Arabia—for years he flew them at all sorts of meetings to illustrate points and for fun, because fun is a terrific teacher. He explained that since he had had to bring two sets of light sources and adapters for a demonstration—our students would be segregated by gender in adjoining rooms—there was no room in his luggage. I asked how large his 'copter collection had become. Here's the Reader's Digest version of what followed:

- The best piece in his small collection of scientific instruments was a sixteenth-century, orrery-like device that maps the motions of Jupiter. His wife, Mickey, had spotted the curiosity and they took it home, later to discover its meaning and rarity. (Alan respected the work of all scientists, even ancient ones. He wanted everyone to appreciate science as he did, and he believed that, given the right tools, everyone could.)
- Speaking of Mickey, she had just finished re-issuing seven mystery titles in e-book form. Alan said the moral of the story was "be sure to get electronic rights for anything you publish, and guard your name." It seems there was another (male) Mickey Friedman who wrote mysteries, which screwed things up for a while. (Ever

the raconteur, Alan made a frustrating escapade in electronic publishing sound downright funny.)

- Speaking of family, Alan asked, "How's Michael now that he's a married man?" He had last seen my son at age eight, but he always seemed to know Michael's actual age and stage of life. Other colleagues might ask after my "little boy," but Alan would keep track. He was my friend as well as my colleague, so he cared about what I cared about.
- Speaking of kids, Alan worried that the New York mayor's single-minded pursuit of extended kindergarten was siphoning support from other important endeavors, like the cultural organizations Alan had worked so hard to defend. (Some years ago, he led the fight against retaliation by the former mayor's office against the Brooklyn Museum for exhibiting scatological art—and won.)
- Speaking of cities, Al Khobar appeared to be a refuge for the wealthy. The mansions were barricaded behind tall fences with elegantly crafted gates. As we walked, Alan photographed gate after gate, stopping to admire one particular gate bearing two lovebirds perched on a branch, in silhouette, in iron work against white opaque glass. It was lovely. Alan had an eye, as well as the urge to document. (In fact, his image collection—many thousands of slides and jpegs of the science museums he visited over the decades—will be catalogued by the Association of Science-Technology Centers and made available to all in late summer 2015.)

Every so often a passing car would honk at the two of us as we crossed a street. We wondered if we had failed to observe an Arabic sign. Or maybe the fact that I was wearing jeans, although my head was covered, was provoking a wolf-whistle. But I didn't worry. Walking with Alan Friedman, I felt safe. He was a man—and a thinker, teacher, leader, and mentor—in whom everyone could have confidence.

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Now retired, Sheila Grinell enjoyed a forty-year career as a leader of science centers. In 1969, fresh out of graduate school, she joined Frank Oppenheimer to create The Exploratorium, a seminal science center widely emulated around the world, serving as Co-director for Exhibits and Programs. Later, she helped restart the New York Hall of Science, serving as Associate Director. From 1993 to 2004 she served as founding President and CEO of the Arizona Science Center, leading the effort to create a new, vibrant institution for greater Phoenix.

For the Association of Science-Technology Centers (ASTC), Sheila created a week-long professional development program for people starting science centers offered 1988-1996. While consulting for a wide range of agencies that included corporations, professional associations, museums, and public television producers, she wrote the leading book on science centers. She was elected a Fellow of both ASTC and the American Association for the Advancement of Science in recognition of her innovative work.

Alan Friedman's Work at the Intersection of Science, the Arts, and the Humanities

Eric Siegel

Dr. Alan Friedman was a brilliant science educator with whom I worked closely for about a decade. Early in our collaboration, he described how the best ideas are found at the intersection of science with the arts and humanities. Throughout his career, Alan explored that intersection, and he was always excited by projects at the New York Hall of Science and elsewhere that drew from the best of the sciences, the arts, and the humanities. In his lifelong exploration of this juncture, he presaged more recent efforts to integrate science with the arts under the banner of STEAM (Science, Technology, Engineering, Arts, and Math). This short article will explore some of Alan's published work in which he very systematically examined the mutual influence among science, art, and the humanities. I will also connect his engagement with the arts and the humanities to his museum work.

Early in Alan's career, he demonstrated a predilection for creating his own path and framework for understanding the impact of science on society. After a successful career as an experimental physicist—he used to describe with relish how he loved putting together experimental apparatus from the kinds of random equipment he found around the lab—he received a fellowship from the National Endowment for the Humanities Basic Research Program. This represented a radical turn away from the career path of his research peers who were pursuing academic positions, postdoc fellowships in physics, and National Science Foundation grants.

The fellowship supported a collaboration with literary critic Carol C. Donley that resulted in a book published in 1985 called *Einstein as Myth and Muse* (Cambridge University Press). Donley and Friedman wrote about how "Einstein's exciting ideas established him as a muse from science, inspiring and supporting interpretation in the arts.... With the explosions of the atomic bomb of 1945... Einstein suddenly came to represent a contemporary version of the Prometheus myth, bringing atomic fire to a civilization unprepared to handle its immense powers." Einstein, they write, is a uniquely central character in the twentieth-century imagination, as he "did not merely move with the flow of cultural history, but cut a new channel across the conventional separations of science and the humanities" (Preface, ix–x). This invites speculation that Alan was inspired by Einstein not only in his scientific endeavors, but also in his desire to "cut a new channel across the conventional separations of science and the humanities."

In the ensuing several years, Alan devoted his energies to the building of programs, audiences, and entire museums, first at the Lawrence Hall of Science at the University of California, Berkeley, then at Cité des Sciences in Paris, and finally at the New York Hall of Science (NYSCI). His signature programs, such as the Science Career Ladder at the NYSCI were notable for how they put human and social concerns at the heart of the STEM learning enterprise. The first permanent exhibition at the NYSCI was called Seeing the Light and was created by the Exploratorium, a science museum in San Francisco that has been the locus of art and science collaboration since the 1960s. Much of that exhibition was created by artists, so from NYSCI's inception, art was at the core of the visitors' experience. Alan also invited collaborations with artists and artists groups such as Art & Science Collaborations, Inc. (ASCI), resulting in a series of commissions, competitions, and installations.

The integration of art into the visitor experience at science centers had a specific focus at NYSCI. Alan's vision, central to NYSCI's mission, was always to make science accessible to diverse learners from different backgrounds. As Dr. Anne Balsamo wrote in her introduction to a catalog of NYSCI-commissioned artwork: "Located as it is in the nation's—and the world's—most ethnically diverse county, [NYSCI] is focused on addressing the diverse learning styles manifested by different visitors…Just as there are people who learn best from a linear and explicit display of scientific phenomena, there are others who draw important insights by contemplating the beauty and suggestiveness of a piece like Shawn Lani's *Icy Bodies*" (Intersections: Art and Science at the NY Hall of Science 2006).

In 1997, Alan wrote a kind of *credo* about his belief in the mutuality of science and art, and why they are both critical for addressing his principal commitment to public education in science. Published originally in 1997 in the journal American Art (11 [3]: 2–7), the article begins with a deep and subtle reading of a pre-Hubble photograph of a cluster of galaxies. To the uninformed eye, particularly one jaded by the dramatic colorized images from the Hubble telescope, the picture has no particular drama. It is a series of small spirals, slashes, and dots of light in a reddish monochrome. Alan systematically uncovers the thrilling nature of discovery embodied in the image. Revealing that there are "trillions of suns" in the image, he systematically walks the reader through the distances involved, which are so great that they are not measured in kilometers, but in light years. The images we are seeing originated several hundred million years ago, and it has taken light all that time to reach us.

He then deftly connects the image to a profoundly contemporary phenomenon, the plasticity of space and time. He writes,

> *Einsteinian space-time tells us, among other things, that this particular arrangement of these galaxies in space and time cannot be thought of as a simple universal image. This photograph is valid from our own place in time and in space, but as seen from other locations in the universe, or even from within the Hercules Cluster itself, these galaxies would never have had this particular arrangement. Infinitely many valid descriptions of the cluster are possible, all different but all related precisely to each other by the equations of Einstein's relativity theory.*
>
> *Simultaneity is one of the most profound casualties of the new Einsteinian view of the universe. Simultaneous events are strictly a local phenomenon, not a universal one. There can be no single snapshot of this cluster of galaxies which is uniquely "correct," because there is no such thing as a "moment in time" for the universe as a whole. We can continue to think of our own time and our own planet as having moments, but we must learn that thinking about the whole universe requires different, less familiar organizing principles and metaphors (2–3).*

Alan is clearly thrilled by the implications of this shift in perspective and wants all of us, young and old, to share that thrill. And this impetus leads him to a surprising turn. "Like most science educators I have thought long and hard about what is wrong with science education in this country. I have concluded that the solution is not just more good science teachers and good science curriculum, but also *more and better arts education* [my emphasis]. That is because what it takes to be astonished and moved by this photograph is not simply learning the names and numbers that go with the image, but *understanding how those facts are part of the larger story of our history, cultural accomplishments, and aspirations*" [my emphasis].

Because Alan was such a lucid and precise explainer, there is no way to summarize this seminal article that is shorter than the article itself. Suffice it to say that the essay draws deeply from poets, novelists, playwrights, and composers past and present to demonstrate the power of the arts not only as a way of understanding science, but as a critical perspective for understanding and constructing reality and a life full of interest and engagement. While he was passionate about the value of the scientific world view, "looking around at my colleagues…I would have a hard time proving that scientists are happier, have more stable marriages, vote more intelligently, or are more effective participants in their broader communities than are people with similarly deep professional commitments to the arts or the humanities."

In 2000, a major essay on the life and work of Remedios Varo written by Alan appeared in a catalog raisonné of the work of this mid-century Mexican artist, who was closely aligned with the surrealist movement in Europe and Mexico. In this essay, he notes that the contemporary rediscovery of her work has taken place among both the science- and art-interested public. Through a close reading of her paintings, Alan carries through his theme of the explanatory power of imagination and the mutual inspiration offered between the arts and the sciences. Varo came of age during the great scientific revolutions of the twentieth century, and Alan's research demonstrates that she read widely among the classic popular science writers of the time such as Fred Hoyle, a particular favorite of both Varo and Alan.

Through this reading, Varo connected the formation of the universe, all its elements, and human beings. Life is built on the elements created during the cataclysms of the early universe. Alan acknowledges that, on the surface, Varo's paintings appear to be influenced by more imaginative worldviews, such as the world of alchemy and magic, but his ability to read the paintings empathetically with the eyes of a scientist and a humanist reveals the deep interweaving of scientific understanding. Alan is an excellent art critic in the Varo catalog, revealing new science-informed richness in the paintings while honoring the centrality of imagination, of beauty, and of the complexity of Varo's worldview. The final paragraph of the essay is resonant and revealing: "The world doesn't have to make sense; but scientists bet their careers that it does. That is their ultimate act of faith. It sometimes makes scientists feel lonely, particularly in cultures where 'bad luck' is a more common explanation than a painstakingly crafted, if only partially successful, model. But scientists believe that the universe is ultimately understandable. I think Remedios Varo shared that faith with us."

A few times a month, I would drop into Alan's office next to mine and ask him to explain some bewildering aspect of contemporary science that I had encountered in my reading— the Heisenberg Uncertainty Principal; "Spooky Action at a Distance" (quantum entanglement); the multiverse; string theory; the twentieth century's panoply of counterintuitive theories that are only distantly comprehensible for laypeople. Alan would patiently walk me through a vastly simplified explanation with no hint of condescension and a sense that there was nothing he'd rather be doing. I was edified and changed by these discussions and I know thousands of others had similar experiences over Alan's lifetime. The breadth of his understanding was reflected in his engagement with the arts and humanities, and his ability to bridge between C.P. Snow's famous "two cultures" is one his great legacies.

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My Boss, My Mentor, My Friend—A Brief Memory

Alan Gould

Alan Friedman was my boss (from 1974-1986), my mentor, and my friend ever since. He was also my ideal example of a true gentleman. Evidence of this came almost every time he would say something. When he was being honored at the 40th Gala Anniversary of the Lawrence Hall of Science, I was struck by how he spoke in his opening words not of himself, but of all the other people who he felt had made important contributions to our collective work.

The first planetarium show I learned to present at the Lawrence Hall of Science was "Stonehenge," and that creation of his still stands among the best audience participation shows I know of. He was so creative and responsive to new ideas. When I came to him with feedback from my audiences, who wanted to see and hear more about the constellations, he went right to work on a new idea that became one of our most successful and replicated shows: "Constellations Tonight." I always use that one as an iconic example of audience participation. Instead of the presenter pointing out constellations and spewing out facts and stories, we start by simply handing out star maps to all the audience members and teaching them how to use them.

I'm proud and honored to be part of the team at the Hall that carries on the legacy of audience participation planetarium shows that Alan pioneered in the Participatory Oriented Planetarium (POP) workshops and the Planetarium Educator's Workshop Guide, which evolved into Planetarium Activities for Successful Shows (PASS; now at http://www.planetarium-activities.org/). To this day we encourage other digital planetariums to include live audience participation in their repertoire of shows, and not to rely simply on recorded programs.

When Alan was President of the International Planetarium Society (1985-1986) I heard him say in a speech that the uniqueness of a planetarium experience comes in no small part from the feeling of community the audience can get by all being together and sharing the experience under the dome. And I'll never forget one of the many things he taught me that comes up again and again. He said that when presenting a planetarium show and deciding what to include, we should always leave the audience wanting more, rather than trying to squeeze every idea and related fact into the show. Getting them excited is more important than cramming their brains with stuff they'll forget anyway. I have found this wisdom to be applicable far beyond planetarium shows, including another expression related to this same idea: that students are not just empty vessels into which teachers should pour their knowledge.

I'm so lucky to have known Alan!

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Alan Gould was Director of the Lawrence Hall of Science Planetarium (UC Berkeley) from 1998-2009. He has over 36 years of experience developing and presenting hands-on science activities and 22 years of experience organizing and leading teacher education workshops. He was also Co-Investigator for Education and Public Outreach for the NASA Kepler mission (2000-2015), co-directs the Hands-On Universe project, and is co-author of Great Explorations in Math and Science (GEMS) teacher guides. Currently he works on the Full Option Science System (FOSS) middle school course revision team and directs the Global Systems Science high school curriculum project at Lawrence Hall of Science.

The Legacy of a Museum Legend

Priya Mohabir

At the core of Alan's vision for the New York Hall of Science (NYSCI) was the commitment to provide the opportunity for high school and college students to develop their interests in science by sharing the experience of discovery with others. For nearly 30 years, the brilliance of that vision has been proven through the many programs Alan created and inspired, most notably the Science Career Ladder (SCL).

Established in 1986, the SCL program began as a series of graduated opportunities that enabled young people to interact with the public by helping visitors to engage with the science behind the exhibits and demonstrations. Combining youth development and youth employment, the SCL provides high school and college students with a meaningful work experience that offers growth through continuous training and peer mentoring.

The creation of the Science Career Ladder captures many of the qualities that made Alan so invaluable to the informal science field. Alan came to the NY Hall of Science when it was effectively derelict. The building was closed to the public and he often recounted how the first time he visited after taking the job there were puddles on the floor. He and his deputy, Sheila Grinell had a knack for finding excellent colleagues, and quickly pulled together a small committed team, including Dr. Peggy Cole and Dr. Marcia Rudy (who is still at NYSCI.) As the first exhibitions came together, Alan realized the need for a corps of floor staff who could greet the public, help to maintain the exhibitions, and generally enliven the visitor experience. The Exploratorium, a science center in San Francisco founded by Frank Oppenheimer, had created a program for Explainers, and that model was the core of a very smart and opportunistic synthesis that Alan and Dr. Cole created. They recruited students from nearby Queens College with interests ranging from theater to physics, and gave them sufficient training to become Explainers, thereby fulfilling an operational need.

At the same time, they recognized a broader need for expert science teachers, and started to shape the Explainer program into the Science Teacher Career Ladder (as it was originally called), and secured significant funding on the hypothesis that this kind of apprenticeship would encourage more young people to become science educators (before the term STEM was born.) This hypothesis turned out to have significant value in encouraging STEM participation, and an early survey documented that over 60% of the early Science Career Ladder cohort went on to careers in STEM fields, the majority of those in STEM teaching.

This, in turn, helped to shape the invaluable Wallace Foundation supported Youth Alive program that disseminated and strengthened youth programs at science centers and children's museums. While Youth Alive was designed to foster youth development across many domains, the Science Career Ladder continued, and continues to this day, to serve the dual purpose of enlivening a visit to NYSCI and fostering STEM careers among its diverse community of participants.

The SCL has become not only a highly recognized program that other institutions have modeled, but also an integral part of NYSCI. The Explainers are the diverse face of our museum, supporting the exploration of science with a range of skills and activities. The SCL's mission is to encourage young men and women from across New York City to pursue STEM careers. Students participating in the SCL demonstrate enhanced science content knowledge, confidence in oral presentations, and strong problem-solving skills, and they show significant growth in communication abilities, interpersonal skills, and leadership.

In its current form the SCL reaches between 120 and 160 young people a year, with about 85% coming from a minority background. As the SCL has evolved, so have the programmatic supports that are offered to participants to expand their skill sets, better preparing them for their next academic and career steps. From career development workshops to opportunities to connect with STEM professionals, the program exposes its participants to a wide range of options that are there for them to pursue.

To honor Alan's contributions to NYSCI and the field at large, NYSCI has established the Alan J. Friedman Center for the Development of Young Scientists through a generous founding grant from the Noyce Foundation. The Friedman Center will encompass the Science Career Ladder program and create opportunities for high school and college students across New York City to explore their prospects in science, technology, engineering and math fields. The goals of the Friedman Center are to develop NYSCI as a resource for youth and community organizations around STEM opportunities, and to create multiple pathways for engaging youth in the STEM career pipeline. As it develops, the Friedman Center will make strategic investments to develop, pilot, and roll out new events and opportunities that broaden our reach to youth in New York City. Alan's memory will continue to be honored and his legacy will live on.

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Priya Mohabir has been with the New York Hall of Science for the last 15 years, starting as an Explainer herself. In her various roles in Education and the Explainer teams, Priya has led numerous projects developing and leading professional development for diverse audiences. As the new Director of the Alan J. Friedman Center for the Development of Young Scientists, Priya will lead the Science Career Ladder as well as the Science Career Ladder Institute. Working with the Explainer leadership team she will continue to develop new and interested opportunities for the Explainers and Residents. We expect to add additional programs to cultivate the interests and careers of young scientists in ways we can only imagine.

Personal Note:
As an alumnus of the Science Career Ladder (SCL) program, the supports I have had along the way have been invaluable. From the motivation to challenge myself to the network of colleagues that I share this experience with, the SCL has supported my professional growth and introduced me to some great friends along the way.

SENCER Synergies with Informal Learning

David A. Ucko

Abstract

SENCER offers a model for integrating aspects of formal and informal learning. This article explores their intersection in the SENCER context, emphasizing the common learner focus and role of relevance in stimulating interest. The SENCER-ISE project further strengthens connections through Higher Education-Informal Science Education partnerships that can bring complementary expertise as well as greater access to the community through public settings and audiences. Applying the lessons learned from the planned evaluation studies will be critical to identifying effective practices and achieving impact at increased scale.

Introduction

This article explores connections between SENCER and informal science education (ISE), expanding on a talk that Alan Friedman invited me to present at the Fourth Annual Science Symposium co-sponsored by SENCER, the National Center for Science & Civic Engagement, and Franklin & Marshall College's Center for Liberal Arts and Society (Ucko 2009). At that time, I served as deputy director of NSF's Division of Research on Learning in Formal and Informal Settings and had known Friedman for many years, since we both had spent most of our careers in the science center field. I had been impressed by similarities between the SENCER approach to aspects of informal learning (and was the "fellow at the National Science Foundation" [Burns 2011a, 2] who helped make a connection). Friedman was instrumental in organizing the subsequent SENCER-ISE invitational conference, which in March of 2011 brought together representatives from both communities to discuss potential synergies. Funding was provided by NSF, and Friedman helped to obtain a Noyce Foundation grant for the conference and then for an initial 10 Higher Education-ISE partnerships. I currently serve as an external advisor, along with Marsha Semmel, on the SENCER-ISE project built upon his legacy.

Informal learning can be defined in a variety of ways (Ucko and Ellenbogen 2008, 241). In general, it is "free-choice," self-directed, and socially mediated. Table 1 lists various attributes of informal learning in contrast with those of formal learning, to identify key differences. Although context dependent and realized to varying degrees, the extremes are represented here in order to accentuate distinctions. This caveat applies both to the "informal" and to the "formal" descriptors, particularly as they relate (or not) to varying modes of higher education.

Connections with Informal Learning

In reviewing outcomes of the SENCER-ISE conference, Friedman and Mappen note that the emphasis on civic engagement provided the "glue" that brought the two communities together (2011, 33). That focus takes advantage of certain strengths of informal learning, several of which they identified, based on an abridged table from the 2009 presentation and the "strands" of the Learning Science in

TABLE 1. Contrasting Attributes of Formal and Informal Learning

Formal Learning	Informal Learning
Compulsory; required	Voluntary; "free-choice"
Content focus	Learner focus
School-based	Ubiquitous; museums, media, etc.
Children & youth	All ages, lifelong
Set times	Any time
Extended time periods	Episodic; often brief
Large peer group setting	Individual, family, or small group
Regular assessment	No tests or grades
Teacher-directed	Self-directed
Cognitive emphasis	Affective emphasis
Extrinsic motivation	Intrinsic motivation
Transmission model	Constructivist; personal meaning-making
Lecture-based	Experiential; hands-on; interactive
Favored learning style	Flexible learning styles
Serious	Enjoyable; engaging; fun
Goal-focused	Exploratory; open-ended
Curriculum-based; "push"	Interest-driven; "pull"
Constrained by curriculum	Unlimited; open-ended; flexible
Predetermined content or focus	Any content or focus
Disciplinary content	Interdisciplinary; trans-disciplinary
May appear irrelevant	Personally relevant

Informal Environments report (NRC 2009). The discussion that follows extends that analysis through comparison with key features of SENCER. (It cannot capture all points of intersection with informal learning, however, since it is likely that the diversity of SENCER courses and settings create additional connections beyond those identified here.)

> "*'Interest' is a driving force in the SENCER ideals*" (Burns 2011b, 9).

Because informal learning is generally voluntary and self-directed, it is motivated by personal interest. The SENCER approach offers a similar means to stimulate student interest and engagement by making connections to "matters that are real, relevant and of vital interest to citizens in a democracy" (Burns 2012, 7). A number of the SENCER-ISE partnerships, for example, involve students in citizen-science activities in which they gather and analyze data related to local, national, or international issues.

> "*They [SENCER courses] are essentially interdisciplinary, so they are more like the world itself than a typical undergraduate curriculum*" (Burns 2011b, 8; see www.sencer.net/Resources/models.cfm).

In general, informal learning experiences are similarly interdisciplinary, since they tend to emphasize real applications and issues rather than particular disciplinary content. Even "Exploratorium-type" science exhibits may involve multiple disciplines, because they are phenomenon based. (For example, the Heat Camera, which reveals the infrared radiation emitted by a visitor's body, demonstrates aspects of both physics and biology.) Like SENCER activities, they are typically "authentic experiences" (Burns 2011b, 8).

> "*SENCER courses and projects that have been designed with students helping all the way just tend to be better. They are more likely to capture something that truly matters to and interests students.... Students can make vital and valuable intellectual contributions to course content and design, development, and refinement*" (Burns 2012, 9).

This aspect of SENCER emphasizes its focus on the learner and the value of involving the target audience in the planning and implementation of the educational activities. That same focus is central to developing informal learning experiences that successfully engage their target audiences and achieve the intended impacts.

> "*It helps to tie assessment to pedagogy (including reflection on course activities like service learning, research, etc); assess frequently and at intervals short enough to enable you to make 'repairs' and mid-course corrections...*" (Burns 2012, 10).

Although informal learning is not assessed as in formal education, evaluation plays a related role. Front-end evaluation seeks to determine audience background and interests to guide the planning of the informal learning experiences. Formative evaluation, through such activities as testing prototypes or a pilot program, obtains feedback at early stages of development when changes are relatively easy to make. Summative evaluation seeks to determine the outcomes and learner impacts of the experiences, whether intended or not. The results can help to improve future development and to address institutional or funder needs. Remedial evaluation is sometimes carried out after completion to make improvements in ongoing programs or exhibits.

SENCER-ISE

SENCER offers a model for synergistically integrating aspects of formal and informal learning to take advantage of the strengths that each offers. The formal course component, for example, brings greater depth than may be possible in informal settings, along with more extended periods of time for the learning activities. In the SENCER-ISE project, formal-informal connections are further enhanced through the active participation of ISE-related organizations that partner with faculty members at a college or university (Table 2).

TABLE 2. SENCER-ISE Partner Organizations

Higher Education Partner	ISE Partner
Antioch College	Glen Helen Outdoor Education Center
Brooklyn College-CUNY	Gateway National Recreation Area
Cornell University	Sciencenter
Fordham University	Wildlife Conservation Society
Hamilton, Hope, and Oberlin Colleges	Green Science Policy Institute
New Mexico EPSCoR	New Mexico Museum of Natural History & Science
Paul Smith's College	The Wild Center
Raritan Valley Community College	New Jersey Audubon Society
St. Mary's College of California	Lindsay Wildlife Museum
University of Connecticut	Connecticut Science Center

In addition to bringing expertise in communicating with the public, partners can also provide a setting and access to an audience and larger community.

Typical higher-education-based ISE relationships focus on communicating aspects of current research to the public through museum programs or exhibits, citizen science, science festivals, science cafés, and other informal learning experiences. Examples range from outreach efforts by individual scientists to national initiatives such as the Nanoscale Informal Science Education Network (www.nisenet.org). Because most of the SENCER-ISE partnerships add a course component, they also create the opportunity to transform undergraduate instruction by strengthening the learner focus through the means previously described. Movement between the different settings and cultures of the formal and informal partners may further enhance student learning through the process of boundary crossing (Akkerman and Bakker 2011). For example, carrying out research that traverses both Cornell's Early Childhood Cognition Lab and the real-world Sciencenter can provide students with a perspective not possible within either domain alone.

In addition, these partnerships offer valuable professional development to the participating faculty and ISE participants, as well as introducing new college student and public audiences to ISE institutions (Friedman and Mappen 2012, 137–139). Perhaps most importantly, they can impact the community in meaningful ways through the activities carried out by students. For example, the Antioch College/Glen Helen project will help reforest a public nature preserve, while the Paul Smith's College/Wild Center will address regional climate change issues by targeting gatekeepers.

Each partnership will carry out its own evaluation to assess the process and outcomes. In addition, a summative evaluation conducted for the project overall will focus on lessons learned from the collaboration between formal and informal partners. Longer-term success will be determined in part by the extent of institutionalization of programs and relationships that lead to sustainability. Findings from these and other studies will be critical to identifying effective practices and steps necessary to increase the scale of this initial undertaking and to amplify its benefits. Addressing SENCER, Wm. David Burns has suggested that "creating and sustaining a community of practice is entirely within our capacity and is necessary to achieving larger scale reforms" (2012, 8). Such a community would benefit greatly from including informal-learning practitioners and researchers among its members. Alan Friedman would have been the first to participate.

About the Author

In addition to consulting at Museums + more; David Ucko co-chairs a National Research Council study on communicating chemistry in informal settings and serves on the Visitor Studies Association board. Previously, he was deputy director for the Division of Research on Learning in Formal and Informal Settings and head of Informal Science Education at NSF, founding president of Kansas City's Science City at Union Station, deputy director of the California Museum of Science & Industry, vice president of Chicago's Museum of Science and Industry, and a chemistry professor at Antioch College and City University of New York. He received his Ph.D. in chemistry from M.I.T. and his B.A. from Columbia College.

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In Memoriam: Alan J. Friedman

Wm. David Burns

The Alan Friedman who telephoned to ask to be excused from working on the SENCER-ISE project for a while so that he could focus on his medical condition was the same Alan Friedman who called on numerous other occasions to say he had a glimmer of an idea or a fully imagined project in mind that would help move the work we are doing from being "nice to necessary."

Two weeks ago, Alan reported that he had received a "very bad diagnosis" but that he had consulted with people he trusted. He expressed confidence in the people at Sloan Kettering and had hopes for a plan of attack that sounded equally audacious and arduous.

Though there was a thin curtain of sadness and apprehension in his voice, Alan's general tone and style differed little in our last call from the many other conversations we had had about other ambitious, arduous, and audacious plans.

"I think we have an opportunity," he would say. And then he would go on to describe an idea he had to encourage formal and informal educators to work for the common good, to strive for what some have called a "perpetual dream" to improve the human condition by enlarging what we all can come to know.

Our last conversation happened on the same day we had previously been scheduled to have lunch. We were to meet at the Century, where of course no business is conducted, so we just planned to talk about the future. Instead, we had that phone call.

On the call with Ellen Mappen and me, Alan spoke with his usual calmness, his usual clarity, in his usual cadence, and with that same curiously wonderful musicality that inhabited each one of his sentences. (Without knowing for sure its source, I have always attributed that sonority to the benefits that come to someone who is as comfortable speaking in French as in English.) He even mustered some humor.

Sensing our shock and our fear, I suspect, Alan took great pains to assure us that getting back to work on our mutual project was a high priority for him. As always, Alan exhibited more concern for our feelings and needs than he expected us to pay to his.

He said he would call us as his health permitted. He asked us to carry on and to share word of his call with only those who needed to know. We were to await further word from him before telling others.

Late last week, when "news" started to come out that Alan was gravely ill, I entertained the comforting illusion that this could have been an extremely bad example of something starting in facts—facts I knew to be true—and descending into rumor. I prayed for an e-mail from Alan bearing the subject line: "News of my demise has been greatly exaggerated."

As the numbers of people close to Alan began to contact one another to share thoughts, tributes, and memories, my hopes grew fainter. We now have word that Alan died yesterday (May 4, 2014).

There will be times and occasions for proper memorials befitting a man of as many parts as Alan possessed and whose career spans so much intellectual space and so many phases in the history and development of informal education.

We will each have our opportunities to add our own meager contributions to what I am sure will be a panoptic body of tributes—a museum of its own, you could say.

For today, however, I only want to let you know that when we spoke that last time, just two weeks ago, I did get to tell Alan that I loved him. Indeed, Ellen was able to say the same and to let him know that Hailey and all in our community who had the great good fortune of working with him closely did so as well. We told him how much it means to us to work with him and we said we would miss him during his temporary absence from our work. We promised him that we would carry on in his absence. So now, in the face of this profound loss, we will keep that promise.

I need time to collect my thoughts, but something I don't need time to think about is my first impression of Alan, an impression that has only grown in intensity in the several years we have worked together.

I remember the day and place I met him. Eliza Reilly had invited us to a SENCER regional meeting she had organized at Franklin & Marshall College. I did a talk, as did Alan.

I had become entranced with something called "informal science education" and had had a chat with some folks at NSF about an idea I had that they, and I am speaking of Al DeSena here in particular, had been particularly encouraging about. I liked my idea (as I tend to), but I was aware just how little I knew about the world of informal science education.

It so happened that Alan, Ellen, and I got seated next to one another at the tables at lunch. Listening to Alan's ideas, responding to his gentle inquiries, and hearing myself reframe my thoughts in response to his, I had an overwhelming sense that an adult had finally entered our conversation!

Though I now know he was only a few years older than I am and though I am blessed to have wonderful colleagues, Alan seemed to me then as he does now to be uncommonly sage, a truly wise man.

I know I am not alone in having that sense of Alan: Alan as the adult, the wise man, the friend, the understanding and patient parent figure, the man willing to lend his luster to your unpolished idea, the man rigorous and demanding of high quality first in himself and then in others, but relaxed and comfortable in manifold and diverse social situations, and, above all, the man who was a quiet, tireless, and amazingly effective worker in the causes that had the extra benefit to be ones that he shared.

The last thing Alan would want is for our memories of him and his legacy to become enshrined or, worse yet, encased, in some old-fashioned specimen display. If ever there were an occasion for a living museum, it is the celebration of Alan's life, his work, and his place in our lives. We will need to become the "living exhibit" of Alan's work.

It is hard taking this in. For many of you, getting to know Alan recently—as recently as it was for me, too—seemed to be more the beginning of what we expected would be a long time of working together, not the premature and abrupt end that confronts us today.

Consolation eludes me.

Perhaps because of its title, but more for what it says to me about the human condition, as well as our need to take time to observe death and mourn, and still to keep going, I think now, not of science, but another way of knowing that was dear to Alan. I recall the words of W.H. Auden:

Musée des Beaux Arts
About suffering they were never wrong,
The old Masters: how well they understood
Its human position: how it takes place
While someone else is eating or opening a window or just walking dully along;
How, when the aged are reverently, passionately waiting
For the miraculous birth, there always must be
Children who did not specially want it to happen, skating
On a pond at the edge of the wood:
They never forgot
That even the dreadful martyrdom must run its course
Anyhow in a corner, some untidy spot
Where the dogs go on with their doggy life and the torturer's horse
Scratches its innocent behind on a tree.

In Breughel's Icarus, for instance: how everything turns away
Quite leisurely from the disaster; the ploughman may
Have heard the splash, the forsaken cry,
But for him it was not an important failure; the sun shone
As it had to on the white legs disappearing into the green
Water, and the expensive delicate ship that must have seen
Something amazing, a boy falling out of the sky,
Had somewhere to get to and sailed calmly on.

I know you will join me in extending our sympathy to Alan's wife, Mickey, and to the remarkable family of Alan's many friends and admirers of which we at the National Center, the SENCER-ISE project, and the SENCER community constitute another small part.

* * *

David Burns is the executive director of the National Center for Science and Civic Engagement (NCSCE), founder and principal investigator of SENCER (an NSF-supported faculty empowerment and curricular reform program), publisher of Science Education and Civic Engagement - An International Journal, and professor of general studies at the Harrisburg University of Science and Technology. He also serves as principal investigator for the National Center's Great Lakes Stewardship Through Education Network (GLISTEN) project, which is supported by the Corporation for National and Community Service, and directs SENCER-ISE, an initiative supported by the NSF and Noyce Foundation, to connect formal science education at the college level with informal science educators (museums, aquaria, science journalists, etc.). He also serves as the principal investigator for Engaging Mathematics, another NSF-supported initiative that applies the SENCER approach to undergraduate mathematics courses. Prior to establishing the National Center, David served as senior policy director for the Association of American Colleges and Universities (AAC&U). During his nine years with AAC&U, he established the Center for Disease Control and Prevention-sponsored Program for Health and Higher Education and created the Summer Symposia dedicated to exploring the power that students have to improve the health of colleges and communities.

For 23 years, David was a member of the administration of Rutgers, the State University of New Jersey. David is the principal author and editor of the book, Learning for Our Common Health, *and, among other publications, the article, "Knowledge to Make Our Democracy." In 2008, the American Society for Cell Biology honored David and SENCER co-founder Karen Kashmanian Oates with the Bruce Alberts Award for Excellence in Science Education. At the state level, David serves as a member of the (NJ) Governor's Advisory Committee on Juvenile Justice and Delinquency Prevention. David's undergraduate and graduate work (at Rutgers) was in political science with a concentration on political theory. He was a Woodrow Wilson National Fellow.*

POINT OF VIEW

Including Civic Engagement as a Component of Scientific Literacy

Martin H. Smith
University of California, Davis

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Youth Scientific Literacy and Nonformal Education Programs

Science is a driving force of twenty-first-century society. As a consequence, related public policy issues (e.g., stem cell research, global warming, food safety and security, water quality and distribution) require informed choices made by a population that is scientifically literate (Committee on Prospering in the Global Economy 2007; Hobson 2008). However, scientific literacy among the adult population in the United States is considered low (Miller 2006), and data from standardized assessments of K–12 youth in recent years have shown poor achievement in science at all three grade levels tested—fourth, eighth, and twelfth (e.g., Fleischman et al. 2010; Gonzales et al. 2008; National Center for Education Statistics 2011).

While improvements in school-based science education represent one way to address the low levels of academic achievement in science among K–12 youth (Smith and Trexler 2006), a growing body of literature suggests that nonformal science programs can help attend to the issue, in part because they emphasize three cross-cutting characteristics of learning: people-, place-, and culture-centeredness (Bell et al. 2009; Fenichel and Schweingruber 2010; Kisiel 2006; Kress et al. 2008; National Research Council [NRC] 2009). Specifically, research findings have shown that out-of-school time (OST) science programming can increase youths' science content knowledge and process skills; additionally, such programs can have positive effects on youths' confidence and interest in science (National Research Council 2009; Stake and Mares 2005).

The 4-H Youth Development Program and Youth Scientific Literacy

The 4-H Youth Development Program is a national nonformal education organization for individuals aged 5–19. Programmatically, 4-H focuses on advancing positive youth development through hands-on educational opportunities that include civic engagement. Complementing its century-long history of offering science projects and programs ranging from geology and minerals to soil conservation, forestry to wildlife and fisheries, and computer science to animal and veterinary science (United States Department of Agriculture

2003), National 4-H established the 4-H Science Mission Mandate in an effort to expand and strengthen 4-H science education efforts through state-based 4-H programs (Schmiesing 2008). The California 4-H Program responded to the National 4-H Science Mission Mandate by commencing a statewide 4-H Science, Engineering, and Technology (SET) Initiative (University of California Agriculture and Natural Resources 2008). This effort focuses on science programming, educator professional development, and evaluation in California 4-H SET, with an emphasis on scientific literacy as it relates to key statewide needs in the areas of natural resources, agriculture, and nutrition (Regents of the University of California 2009).

Defining Scientific Literacy to Advance 4-H Science Programming

To achieve improvements in youth scientific literacy through nonformal education programs, we need to go beyond just developing new programming and strengthening what is already in place. First, it is important that science education programming be relevant and useful to learners, providing them a context for understanding and using scientific information (Millar 2008; Zeidler and Nichols 2009). Secondly, it is imperative that educators who implement nonformal science education programs with youth engage in effective professional development (Smith and Schmitt-McQuitty 2013). Lastly, data are needed to demonstrate that nonformal science education programs are succeeding in achieving their objectives; to accomplish this, however, there is a need for systematic, efficacious assessment strategies (Hussar et al. 2008). Understanding these criteria, and taking a closer look at the science education opportunities in California 4-H, we acknowledged the absence of a framework that would provide for a systematic and intentional approach to addressing science education programming, including development, implementation, educator professional development, and assessment.

To develop a framework, researchers and program staff began by asking the question: What does it mean to be scientifically literate within the context of California 4-H? However, despite a plethora of existing definitions of scientific literacy (Roberts 2007), there was no consensus about the meaning that allowed us to answer this question. This is a critical first step: a definition for the construct of scientific literacy is necessary to develop and advance science programming (Roberts 2007). Thus, our efforts to advance science programming in California 4-H began by framing a definition of scientific literacy (Smith et al. 2015).

A review of the literature revealed that most existing definitions of scientific literacy are not contextualized; rather, they focus on a broad array of science concepts and processes considered important to scientists (Falk et al. 2007; Laugksch 2000; Roberts 2007) but ignore "the social aspects of science and the needs of citizenship" (Lang et al. 2006, 179). In contrast, when viewing science learning as being contextualized, referred to as a "focus-on-situations" approach, programming places an emphasis on authentic science-related issues that individuals may encounter (Roberts 2007). Because of the contextualized nature of 4-H, we concentrated on developing a definition of scientific literacy that would accommodate relevant science programming across multiple contexts and include civic engagement, a hallmark of the 4-H experience (Brennan et al. 2007; Hairston 2004). By considering the construct of scientific literacy from this perspective, the definition developed for the California 4-H Program includes four *anchor points*: science content, scientific reasoning skills, interest and attitude, and contribution through applied participation. The four *anchor* points are described further as follows:

- **Anchor Point I:** Science Content. Content knowledge is an important component of any definition of scientific literacy (NRC 2007; NRC 2009; Roberts 2007). A "focus-on-situations" approach places the emphasis on science-related content relevant to the citizens of California (e.g., water resource management, sustainable food systems, sustainable natural ecosystems, food safety and security, management of endemic and invasive pests and diseases, energy security and green technologies, and nutrition education and childhood obesity) that have been identified as germane to the state's citizens (Regents of the University of California 2009).

- **Anchor Point II:** Scientific Reasoning Skills. The advancement of scientific reasoning skills encourages learners to become more proficient in the practices of science by asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, engaging in argumentation from evidence, and obtaining, evaluating, and communicating information (NRC, 2012). Referred to by Colvill and Pattie as the "'building blocks' of scientific literacy" (2002, 20), scientific reasoning skills provide learners with the necessary abilities to participate in scientific investigations, challenge conclusions, and question understanding.

- **Anchor Point III:** Interest and Attitudes. Enhancing interest in and attitudes toward science can influence individuals in a variety of ways: it can stimulate their interest in science careers, help guide their responses to science-related situations in their everyday lives, and enhance their motivation to become involved in science-related issues in meaningful ways as citizens (Bybee and McCrae 2011). This is especially germane to audiences that have had limited educational opportunities in science, including women and ethnic minorities (Else-Quest et al. 2013; Scott and Martin 2012).

- **Anchor Point IV:** Contribution through Applied Participation. The application of knowledge and skills in authentic contexts helps individuals gain a deeper understanding of scientific concepts and develop their abilities to think critically (Jones 2012). Furthermore, *Anchor Point IV* is particularly relevant to 4-H youth and the development of citizenship and life skills through civic engagement opportunities. Specifically, youth apply new knowledge and skills in ways that help address authentic community needs they have identified as important (e.g., Smith 2010).

Conclusion

Twenty-first-century society requires a scientifically literate citizenry (Hobson 2008; Committee on Prospering in the Global Economy 2007). Scientific literacy among youth populations is low (e.g., National Center for Education Statistics 2011), and nonformal science programs can help attend to this issue (e.g., Fenichel and Schweingruber 2010). However, to accomplish this, a definition of scientific literacy is needed (Roberts 2007). In California 4-H, we developed a definition of scientific literacy that includes the engagement of youth in science-related issues at the community level. Involving youth in service opportunities results in contributions to the community and advances the youths' development (Brennan et al. 2007). Furthermore, by engaging youth fully in community-based change efforts they learn to function effectively in society (Nitzberg 2005).

Organizationally, California 4-H science programming is grounded in constructivist-based pedagogical strategies. Specifically, learning opportunities utilize guided inquiry-based instruction embedded in a five-step experiential learning cycle that places an emphasis on the authentic application of new knowledge and skills—the point where civic engagement intersects with 4-H science programming. To date, however, California 4-H has lacked a coherent framework to guide the key elements of science programming—the development of new curricula, the adaptation of existing curricula, educator professional development, and assessment efforts—in a manner that, by design, includes civic engagement.

The definition of scientific literacy that was developed will provide a programmatic structure for all elements of science programming in California 4-H; it will also afford a consistent, systematic strategy that will allow for the comparison of 4-H science programs within and across contexts (e.g., 4-H clubs, camps, afterschool programs), the evaluation of pedagogies, and assessments of targeted learner outcomes (Roberts 2007). Furthermore, the definition of scientific literacy in California 4-H intentionally includes the social aspects of science by engaging youth directly in relevant community issues. Such civic engagement is a key component of 4-H programming; in a larger context, however, it is essential to helping develop an informed public that is faced ever more frequently with decisions on science-related public policy issues.

About the Authors

Martin H. Smith, M.S., Ed.D. The overarching goal of Smith's work is to develop, evaluate, and publish effective, research-based science curricula and educator professional development models for school-based and nonformal education programs. Specifically, he focuses on educational materials and strategies that emphasize constructivism, reflective practice, and situated learning. His current work focuses on applied research related to youth scientific literacy in the areas of bio-security and water science education. He is also engaged in efforts to develop a theoretical basis for science education programming within California's 4-H Youth Development Program, with an emphasis on defining scientific literacy, defining curriculum, and implementation fidelity. In his tenure at UC-Davis he has supervised twenty graduate fellows from science disciplines in education outreach work through the School of Education, has served on committees for graduate students (M.S. and Ph.D.), and has mentored over 450 undergraduate students involved in a wide variety of research, development, and extension efforts.

Steven Worker coordinates the California 4-H Science, Engineering, and Technology (SET) Initiative, an effort to strengthen youth science education in the 4-H Youth Development Program. Worker is a Ph.D. candidate at the UC Davis School of Education and is engaged in a qualitative case study of the co-construction of design-based learning environments by youth and adult volunteers in out-of-school time.

Andrea Ambrose, who serves as the acting director of the University of Ccalifornia Agriculture and Natural Resources Development Services, has thirty years of professional experience in the out-of-school education field including more than twenty years as an art and science museum educator, program developer, and fundraiser for organizations in Colorado, California, and West Virginia. She has taught standards-based science and art workshops for K–12 students, conducted professional development programs for K–12 educators, worked with and managed youth and adult volunteers, and secured significant funding from corporations, foundations, and public agencies for programmatic and capital projects. Her efforts to elevate the quality of out-of-school time programs for young people continue as she works to facilitate strong programmatic and funding partnerships on behalf of the University of California 4-H program and the UC Division of Agriculture and Natural Resources. She holds a B.A. in Studio Art and Art Education from Colorado State University and an M.A. in Art History from the University of Oregon.

Lynn Schmitt-McQuitty works as a county-based faculty member for the University of California Cooperative Extension and serves the geographic region of Santa Cruz, Monterey, and San Benito Counties with youth development programming in nonformal science. Her scope of work is focused on developing multidisciplinary and integrated approaches to addressing California's and the nation's decline in youth science performance and achievement. This is accomplished by conducting applied research, education and programs with nonformal educators utilizing effective professional development models, curricula, and deliveries, to engage youth in self-directed learning and discovery.

Schmitt-McQuitty graduated from the University of Wisconsin at Stevens Point in 1987 with a B.S. degree in Elementary Education with an emphasis in Outdoor Education, and obtained her M.S. degree in Outdoor Education in 1991 from Northern Illinois University.

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POINT OF VIEW

Engaging Parents in Early Childhood Learning: An Issue of Civic Importance

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Abstract

There is a gap between what researchers know about early childhood cognitive development and how some adults interact with children in their care. We see evidence of this every day at the Sciencenter in Ithaca, NY. Giving parents the tools and confidence to encourage their children's scientific exploration and engaging parents in current research is a topic of civic importance. The Sciencenter has partnered with Cornell University's Early Childhood Cognition Lab on a Science Education for New Civic Engagements and Responsibilities - Informal Science Education (SENCER-ISE) project to engage undergraduate students in this topic. As a result of this project, we are confident that the students see early childhood development not only as something they are researching, but as a topic of civic importance. In turn, this partnership allows the Sciencenter to integrate research into our programs to improve the learning environments for young children in our community.

At the Sciencenter, a hands-on science museum in Ithaca, NY, we watch young children learn through play. They explore, make observations and inferences, and perform experiments just like scientists. What we see every day on the museum floor has also been researched and documented at Cornell's Early Childhood Cognition Lab and other labs around the country. Children make inferences about cause and effect and use statistical evidence to make predictions about their world (Kushnir and Gopnik 2005; Kushnir et al. 2010). The same curiosity that leads to exploratory play also leads to explanation-seeking behavior. Children ask "why" when events are unexpected or surprising (Legare et al. 2010). In other words, young children, given the opportunity to explore, do so in the same ways that scientists do.

At the Sciencenter, we have also learned that not all children have the opportunity to experience rich play environments and the freedom to explore and experiment. There is a gap between what researchers know about early childhood cognitive development and how some parents, caregivers, and educators interact with the children in their care. We see evidence of this knowledge gap every day as parents and caregivers interact with their children at our exhibits and out in the world. We see parents concerned that their children will get too wet if they play with water, or parents who move their children along to new activities when the children are engaged in repetition to see if the outcome stays the same.

Giving parents the tools and confidence to encourage their children's scientific exploration and engaging parents and caregivers in current research in cognitive development are matters of civic importance, and time is of the essence.

Early childhood is a time of rapid development. By age three, for example, children have already learned 50 percent of what they will eventually know as adults (Landry 2005). Young brains start pruning neural connections that go unused at age four, and—remarkably—children's brains are 90 percent fully developed by age five (Woodhead 2006). We believe that giving parents the confidence and tools to allow their children to explore like young scientists will help create the best learning environments possible for young children and set the stage for future learning.

Since 2012, researchers from Cornell's Early Childhood Cognition (ECC) Lab have been using the museum floor at the Sciencenter as a research space. By working at the Sciencenter, ECC Lab researchers are able to recruit child participants for their studies. The ECC Lab is discovering how children think and learn while they are playing games with puppets and stickers. One recent study, conducted at the Sciencenter, looked at the effect of choice on sharing behavior (Chernyak and Kushnir 2013).

While children participate in research, their families are able to watch research in action and discuss the latest theories about how children learn with real scientists in this "living exhibit."

The Science Education for New Civic Engagements and Responsibilities-Informal Science Education (SENCER-ISE) partnership project gave us the perfect opportunity to leverage this research partnership and engage undergraduate students in real-world learning while giving parents the tools and confidence to support their children's explorations. As one undergraduate participant said, "In the lab, we examine children's learning and thinking using activities and games specifically designed for a controlled lab setting.... This project examines children's learning in the organic and messy real world to see how they learn in informal learning environments."

As part of the SENCER-ISE project, Cornell undergraduates have helped develop and test signs to encourage parents and children to make connections between different exhibits and other areas of their lives through the use of common vocabulary. The first set of exhibit signs has the word "water" and an image of a water drop. The signs are placed on aquariums, water play areas, and a model of human blood. Undergraduate researchers from the ECC Lab are studying the kinds of parent-child conversations that arise as a result of the prompt from the signs. This is a real-world application of a theory undergraduates learn in their "Concepts and Theories in Childhood" course: children expect to find commonalities between things that are labeled with the same word. As is always true in the real world, there have been some surprises. Student researchers have found that "parents and children engaged in meaningful and purposeful play at the water exhibits." "Parents were also likely to ask their children causal and predictive questions, as well as offer causal explanations to their children's questions." The results also indicated, however, that the signs did not promote conversations. In fact, "while parents and children engaged with exhibit materials, they rarely noticed the signs." That is why in the second year of the SENCER-ISE grant, we have introduced a "scavenger hunt" to encourage children to search for the signs.

In addition, undergraduate and graduate students have shared current research at workshops for parents and teachers both at the museum and at Head Start sites in the county. Since 2014, over 460 adults have attended these workshops, which highlight some of the research into early childhood cognitive development and provide tools to support their children's science exploration. Early childhood teachers have learned that even young children can and do use science and science skills, and have practiced science process skills. Through these workshops, undergraduate researchers have had the opportunity to apply their theoretical learning about early childhood cognition in an informal setting, creating richer learning experiences for them as scientists and students of children's learning.

As a result of the SENCER-ISE project, we are confident that the undergraduate students see the topic of early childhood development not only as something they are researching, but as an issue of civic importance. They experience the real-world applications of their theoretical learning and see the differences between learning environments and parenting styles firsthand.

In turn, we at the Sciencenter have access to current research and expert advisors so that we can continue to integrate research into exhibits, programming, and our outreach efforts in ways that improve the learning environments for the young children in our community. We have been honored to be a part of the SENCER-ISE project and look forward to continuing this work.

About the Authors

Michelle Kortenaar serves as the Director of Education at the Sciencenter, a position she has held since 2011. Ms. Kortenaar has a formal science education background, both as a master teacher and as a department head at the middle and high school levels, as well as 6 years of informal science education experience. She has a degree in education from Queen's University in Ontario, Canada.

Allison Sribarra has been the Grant Administrator at the Sciencenter since 2012. She has worked closely with Sciencenter educators on early childhood programming. She has a decade of experience working with non-profit grant management and administration and holds a master's of public policy from the University of Maryland.

Tamar Kushnir is Associate Professor at the College of Human Ecology at Cornell University. She received her M.A. in Statistics and Ph.D. in Cognitive Psychology from the University of California, Berkeley, and was a Post-Doctoral fellow at the University of Michigan. Dr. Kushnir's research examines mechanisms of learning in young children. She continues to explore the role that children's developing knowledge - in particular their social knowledge - plays in learning, a question with implications for the study of cognitive development as well as for early childhood education.

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PROJECT REPORT

Midshipmen-Facilitated Informal STEM Education

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Abstract

The nation's security relies heavily on future STEM talent with scientific and technical skills, which is why the United States Naval Academy (USNA) encourages midshipmen (all USNA undergraduates) to facilitate informal STEM education outreach events for K–12 students and teachers. This experience prepares the midshipmen as problem solvers, effective communicators, and leaders—all necessary attributes for officers in the United States Navy and Marine Corps—while encouraging more young people to be STEM-literate citizens and pursue STEM careers in Navy-relevant fields. Using event-specific pre- and post-surveys, we measured the gains that midshipmen made in communication, confidence, and leadership as a result of their facilitation experience. In addition, analysis of overall STEM Impact Survey results reveals that midshipmen's participation in informal STEM outreach improves their motivation to remain in the STEM pipeline. This study will be useful for assessing gains made by activity educators, judges, mentors, or facilitators of other informal STEM outreach programs.

Introduction

It is not a sight you see every day: a midshipman from the United States Naval Academy (USNA) helping a fifth-grader glue washers onto a small piece of metal. After the midshipman describes how an underwater glider moves through the ocean, the student chooses a launch angle and releases her newly ballasted glider into the tank. She is delighted when it travels farther than previous attempts. This student is engaged in Navy-relevant project-based learning, and the midshipman is one of many who facilitate informal STEM education through USNA's STEM Center for Education and Outreach (STEM Center).

Many organizations (educational, private, commercial, and governmental) offer, host, or support informal STEM education opportunities (Bonney et al. 2009; Committee on Science and Technology 2009; Harlow 2012; Phillips et al. 2007). This can take many forms such as hosting a Family Science Night, judging a science fair, mentoring future scientists and engineers, promoting citizen science, or supporting competitions such as the FIRST Robotics or MathCounts.

The primary goal of these activities is to increase STEM awareness and access community-wide. In order to gauge these efforts, organizations study participant gains made as a result of the informal event, usually through the use of surveys. Often overlooked in this process is the impact of the informal STEM activity on the educator, judge, mentor, or facilitator.

The Navy's interest in STEM education comes as a response to the military's struggle to recruit people with essential STEM experience, especially those from underrepresented groups, for both civilian and military positions (Committee on STEM Workforce Needs for the U.S. DOD 2012). Nationwide, policymakers and scholars often lament leaks or reduced input into the STEM pipeline of future science and engineering talent (Committee on STEM Workforce Needs for the U.S. DOD 2012; Hernandez et al. 2013; Korpershoek et al. 2013; Kubel 2012).

The STEM pipeline is a common metaphor describing the ever-narrowing conduit of people flowing from high school graduation, entering college, choosing a STEM major, graduating from college with a STEM major, and entering a STEM career (Cannady et al. 2014). Indeed, the Department of Defense (DOD) "hires more scientists and engineers, and sponsors more research and development projects that any other federal employer" (Miller 2011, 42). With that in mind, the goal of the USNA STEM Center is to encourage more young people to pursue STEM careers (especially in technical fields relevant to the Navy), to engage K-12 students and teachers in STEM innovation and project-based learning (PBL) methodology, and to increase retention of USNA STEM majors by engaging them in education outreach.

For STEM Center events, the informal learners are K–12 students or teachers nationwide, and the facilitators are USNA faculty and undergraduate midshipmen volunteers. Representing a cross-sector collaboration between the Navy, education practitioners, our sponsors (Office of Naval Research, Office of the Secretary of Defense, Naval Academy Foundation), and event-specific partners (Maryland Mathematics Engineering Science and Achievement [MESA] and National Oceanic and Atmospheric Administration [NOAA]), these events fulfill a civic need to engage participants in STEM education and innovation in order to meet national security needs. Events include SeaPerch competitions and builds, Girls Days, MESA Days, Summer STEM Camps, STEM Educator Training (SET) Sail workshops, and Mini-STEM events. Most events utilize a workshop format in which participants join 30- to 60-minute modules focused on a particular topic (fluid mechanics, alternative energy, applied math, robotics, engineering design, applied science, and others). Modules are largely hands-on, combining the scientific method with the engineering design process, and emphasize essential naval applications of STEM innovation.

The autonomy and magnitude of midshipmen facilitator roles vary from event to event. For example, Girls Day events have a USNA faculty lead facilitator for each module and two to four midshipmen assistant facilitators, whereas MESA Day modules are entirely operated by midshipmen facilitators. They have complete control over the module setup, organization, and presentation; only the content is loosely provided to them by STEM Center faculty, and active learning pedagogy encouraged. Both Girls Day and MESA Day events will be explored later in this article.

Review of Literature

Although considerable literature has focused on the impact of informal education among participants (Committee on Science and Technology 2009; Dierking and Falk 2010; Falk and Dierking 2000; Falk and Storksdieck 2010; Learning in the Wild 2010; Schwan 2014), research exploring facilitator gains made as a result of informal education is limited, focusing on either preservice teachers, formal service-learning, or mentorships. An informal education facilitator is one that arranges resources, establishes rich experiences, and engages with participants to promote learning (Schunk 2012). Harlow (2012), McDonald (1997), and McCollough and Ramirez (2010) investigated gains made by preservice teachers serving as Family Science Night facilitators. They each found that, as a result of informal science facilitation experience, preservice teachers gained confidence in their ability to teach and communicate science, improved in their understanding of the public's prior science knowledge and preconceptions, and honed STEM education techniques to maximize public engagement. Similarly, Crone et al. (2011) found that the training of science and engineering graduate students in informal education yielded gains in student communication and evaluation skills.

Other researchers specifically explored undergraduate science majors involved in K–12 outreach as part of a formal service learning project (a combination of formal classroom learning with community service). Roa et al. (2007) found that undergraduate participation in K–12 science outreach increased confidence, boosted communication skills, linked knowledge with application, promoted identity-building, influenced career choices, and assisted in undergraduate retention of science majors. Both Gutstein et al. (2006) and Sewry et al. (2014) noted enhanced learning, academic development, and improved perceptions of science applications in society among undergraduate facilitators. LaRiviere et al. (2007) reported undergraduate chemistry majors learning and appreciating how children conceptualize science as a result of science education outreach.

Additional research investigated STEM undergraduate gains after mentoring young women who were considering a STEM career. Mentoring involves advising others on strategies and skills in a professional context (Schunk 2012). Chan et al. (2011) found that female undergraduate mentors majoring in biomolecular science experienced improved patience and communication as a result of their outreach mentoring experience to seventh graders. Furthermore, Amelink (2009) argues that mentoring benefits both mentor and protégé. Specifically, the mentor gains a sense of accomplishment, a boost in self-confidence, an augmentation in communication skills, and a feeling of personal validation. In addition, mentoring likely improves the retention of undergraduates in STEM fields (Amelink 2009).

Purpose

The above literature review indicates observable advantages for higher education students serving as outreach facilitators. However, no study yet exists investigating undergraduate STEM majors serving voluntarily as ISTEM facilitators for the K–12 community. Therefore, the purpose of this study is to explore the gains that USNA midshipmen made as a result of facilitating ISTEM outreach events. Guiding questions include (1) Do midshipmen demonstrate improvements in leadership, communication, and confidence after facilitating ISTEM events? and (2) Does participation in ISTEM improve midshipmen's motivation to continue in the STEM pipeline? These questions can help to assess the gains made by activity educators, judges, mentors, or facilitators of other STEM outreach programs.

Theoretical Framework

Constructivist learning theory presupposes that learners actively construct their own knowledge (Kruckeberg 2006; Schunk 2012). STEM Center events are designed under the constructivist assumption that knowledge develops inside active learners through engagement in hands-on activities (Piagetian constructivism) and social interactions (Vygotskian constructivism). Furthermore, constructivists also assume that educators serve as facilitators, structuring environments for learners to actively engage with content and materials (Schunk 2012). In this sense, we postulate that informal education facilitators also actively learn from their experience in facilitating hands-on activities and interacting with event participants. Alan Friedman expressed a similar view in an interview with Ellen Mappen: "When you try to teach a concept to others your own understanding is really tested and improved. So I think undergraduates who learn to communicate science to informal audiences…have a unique experience that sharpens their own knowledge and communication skills" (Friedman and Mappen 2011, 35).

Methodology

USNA midshipmen involved in STEM Center outreach were surveyed for particular ISTEM events (Girls Day and MESA Day) and overall STEM outreach impact in 2013 and 2014. Survey questions were adapted from Assessing Women and Men in Engineering mentor surveys (Assessing Women and Men in Engineering 2014).

Event-Specific Surveys

Girls Day. Printed, anonymous pre- and post-surveys were administered to midshipmen facilitators of two Girls Day events: one on October 19, 2013 and the other on March 1, 2014. Survey responses were later entered into an electronic survey created using Google Forms for compilation and analysis. Girls Day is a one-day ISTEM event hosted at USNA in which 215 (on October 19, 2013) and 221 (on March 1, 2014) middle-school girls participated to explore STEM concepts and careers using PBL. Activities at each Girls Day include modules on astronomy, weather, fluids, bioterrorism, rockets, robotics, physics, engineering design, and others. Each Girls Day module has a lead USNA faculty facilitator, who supervises two to four midshipmen facilitators. Approximately forty-eight midshipmen facilitated the October 19, 2013 event.

Twenty-four pre-surveys and seventeen post-surveys were collected on that day. The March 1, 2014 event was facilitated by approximately thirty-one midshipmen, with twenty-one pre-surveys and eighteen post-surveys being collected (Table 1). Pre-survey questions employed multiple choice or Likert scale. Post-survey questions employed multiple choice, Likert scale, and open-ended response. Similar Likert scale questions appeared on both pre- and post-surveys to measure changes as a result of event participation:

1) *As a leader for a STEM activity, how much ability do you have for each of the skills listed below? (Likert scale response: None, Some, Good, Excellent)*

- *Ensure that participants are satisfied with their participation in an activity*
- *Deliver an effective explanation of an activity to the participants*
- *Take charge of leading a portion of a student activity*
- *Solve a conflict between participants effectively*
- *Motivate participants to actively engage in an activity*
- *Teach a hands-on skill, after being trained*
- *Adjust activities when things aren't going as planned*
- *Positively influence younger children through your leadership*
- *Communicate with diverse audiences (age, ethnicity, region)*

Other questions appeared only on the post-survey:

2) *Please respond to these items that will help us improve the activity that you participated in. (Likert scale response: NO, Strongly Disagree; Disagree; Neutral; Agree; YES, Strongly Agree)*

- *The organizers adequately supported me in fulfilling my assigned duties.*
- *If I needed help in solving problems during an activity, it was readily available.*
- *I had adequate information about the activity and my role in order to do a good job.*
- *I had adequate training to prepare me to effectively perform my leadership role.*
- *From my point of view, the students I led are satisfied with my performance.*
- *From my point of view, the students I led found participation worthwhile.*
- *This activity was well organized.*
- *This activity should be offered again.*
- *My participation in this activity led me to a better understanding of a STEM field.*
- *My participation in this activity led me to a fuller exploration of my own career goals.*
- *My participation in this activity makes me more confident in my own ability to succeed in a STEM field.*
- *My participation in this activity improved my leadership skills.*

3) *What are two things you learned by participating in this STEM event?*

4) *What was effective about the way this event was organized?*

5) *What needs to be improved the next time this event is offered?*

Finally, a paired sample t-test was conducted to compare pre- and post-survey questions that appeared on both instruments.

MESA Day. Printed, anonymous pre- and post-surveys were administered to midshipmen facilitators of two MESA Day events: one on November 22, 2013 and the other on November 5, 2014. Survey responses were later entered into an electronic survey created using Google Forms for compilation and analysis. Pre- and post-survey questions were exactly the same as Girls Day survey questions. MESA Day is an event held in collaboration with Maryland Mathematics Engineering Science Achievement (MESA). For each MESA Day, midshipmen stage and facilitate a full day of hands-on modules (robotics, buoyancy, water properties, polymers, engineering design, and more) for approximately 250 fifth-grade students from local schools at the Johns Hopkins Applied Physics Laboratory. Thirty-three (on November 22, 2013) and thirty-four (on November 5, 2014) midshipmen facilitated each MESA Day, exercising complete control over module set-up, organization, and presentation. Thirty-three pre-surveys and twenty-seven post-surveys were collected for the November 22, 2013 event, and thirty-four pre-surveys and thirty-four post-surveys were collected on November 5, 2014 (Table 1). A paired sample t-test was conducted to compare pre- and post-surveys. For the November 5, 2014 post-survey, responses to the open-ended question "What are two things you learned by participating in this STEM

TABLE 1. Rate of return for event survey responses.

Event	Number of Midshipmen Facilitators	Rate of Return (Pre-Survey)	Rate of Return (Post-Survey)
Girls Day (Oct 19, 2013)	48	50%	35%
Girls Day (Mar 1, 2014)	31	68%	58%
MESA Day (Nov 22, 2013)	33	100%	82%
MESA Day (Nov 5, 2014)	34	100%	100%

TABLE 2. Rate of return for STEM Impact survey responses.

Survey	Number of Midshipmen Emailed Survey	Rate of Return
STEM Impact Survey 2013	84	50%
STEM Impact Survey 2014	104	63%

event?" were categorized and tabulated based on subject occurrence such as communication, leadership, or facilitation.

STEM Impact Survey

An anonymous STEM Impact Survey was created using Google Forms and administered via email on December 20, 2013 to eighty-four midshipmen with over six hours of STEM outreach participation during fall semester of 2013, and on December 12, 2014 to 104 midshipmen with over six hours of participation during fall of 2014. The 2013 survey had forty-two midshipmen respondents, and the 2014 survey had sixty-five respondents (Table 2). Survey questions employed multiple choice or Likert scale:

1) *Please respond to these items to describe how participation in STEM outreach has impacted you. (Likert scale response: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree, Not Applicable)*

- *My participation in STEM outreach made me more confident in my own ability to succeed in a STEM field.*
- *My participation in STEM outreach influenced me to choose a STEM major.*
- *My participation in STEM outreach influenced me to stay in a STEM major.*

2) *How has your participation in STEM outreach influenced you as a student?*

3) *If applicable, please describe how participation in STEM outreach influenced you in selecting or staying in a STEM major.*

Question 3 appeared only on the 2014 STEM Impact Survey, not on the 2013 survey. All other questions were the same on both instruments. Likert responses indicating "Not Applicable" were removed from the analyzed data set.

Results and Discussion

Event-Specific Surveys

Comparison of pre- and post-surveys for the March 1, 2014 Girls Day (Figure 1) and the November 5, 2014 MESA Day (Figure 3) indicated improvement in all leadership categories as a result of event participation: communication, improvisation, teaching ability, conflict resolution, module management, and concept clarification. Specifically, midshipmen facilitators on Girls Day experienced the greatest gains in their ability to motivate module participants (10.9 percent), adjust activities spontaneously (10.1 percent), communicate with diverse audiences (8.7 percent), and teach a hands-on activity (6.5 percent) (Figure 2). Three of these gains were statistically significant using a paired sample t-test: motivate module participants, $t(12) = 1.90$, $p = 0.08$; communicate with diverse audiences, $t(12) = 2.74$, $p = 0.018$; teach a hands-on activity, $t(11) = 2.16$, $p = 0.054$. Midshipmen facilitators on MESA Day indicated greatest gains in their ability to adjust activities spontaneously (9.5 percent), solve a conflict between participants effectively (8.8 percent), positively influence younger children (5.2 percent), and ensure participants are satisfied with their participation (4.4 percent) (Figure 4). All of these gains were statistically significant according to the paired sample t-test: adjust activities spontaneously, $t(30) = 3.24$, $p = 0.003$; solve a conflict effectively, $t(30) = 1.97$, $p = 0.058$; positively influence children, $t(30) = 2.24$, $p = 0.03$; ensure participants are satisfied, $t(30) = 2.52$, $p = 0.017$.

Originally, we anticipated that MESA Day would yield greater leadership gains overall compared to Girls Day, because the event allows midshipmen greater ownership and influence as facilitators. However, this was not consistently the case. The 2014 MESA Day event, in which midshipmen had more control over module execution, yielded greater gains in midshipmen's ability to solve conflict between participants and to positively influence young children than did Girls Day. On the other hand, 2014 Girls Day midshipmen reported greater gains in ability to motivate and engage girls in activities, to teach a hands-on skill, and to communicate with a diverse audience compared to MESA Day. We suspect the greater gains displayed among Girls Day midshipmen was due to the large number of first-time outreach midshipmen participants for that event. Eight of the twenty-one

FIGURE 1. Midshipmen self-evaluation of STEM leadership abilities as a result of facilitating Girls Day on March 1, 2014.

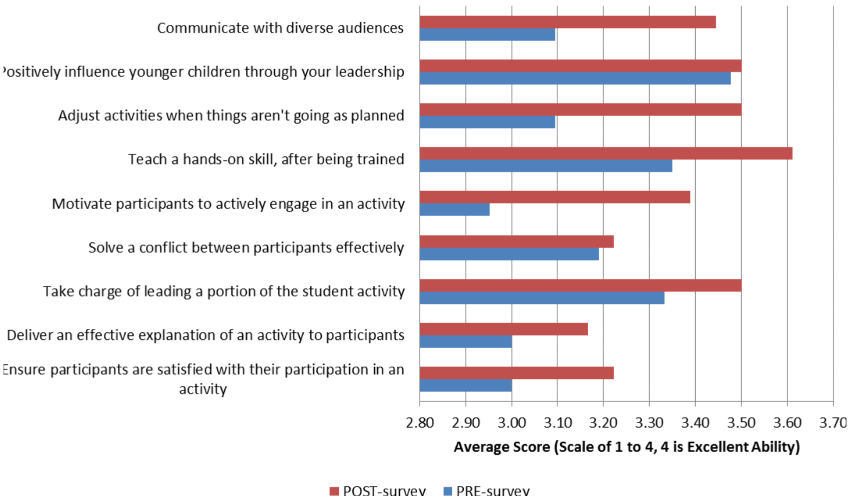


FIGURE 2. Percent positive increase in midshipmen self-evaluation of STEM leadership abilities for Girls Day on March 1, 2014.

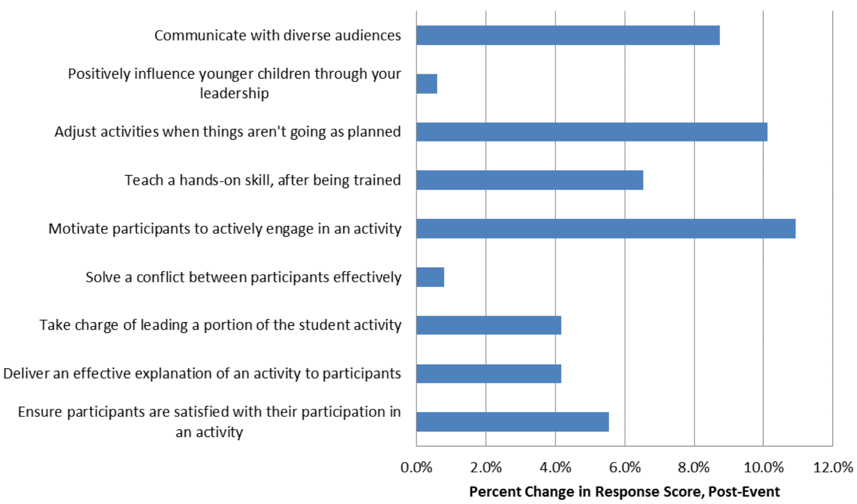
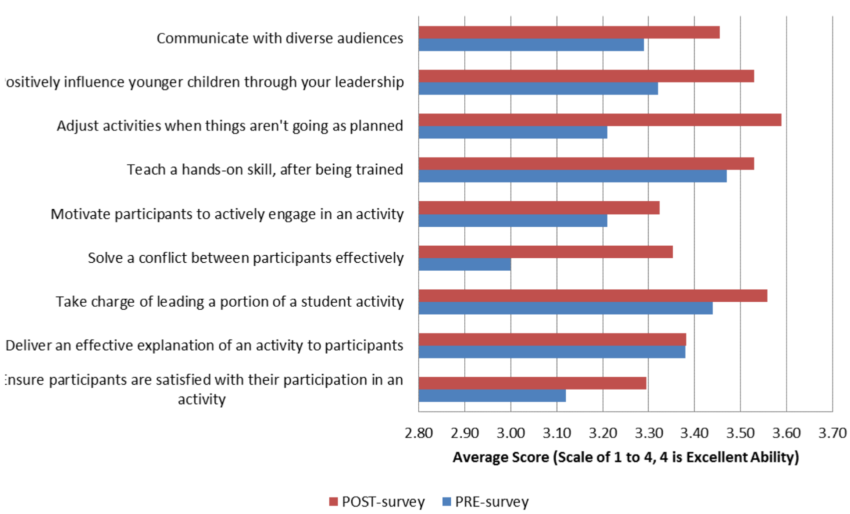


FIGURE 3. Midshipmen self-evaluation of STEM leadership abilities as a result of facilitating MESA on November 5, 2014.



midshipmen (38 percent) facilitating the 2014 Girls Day rated themselves as *"I have not yet participated in a STEM activity"* on the pre-survey. On the other hand, only three of the thirty-four midshipmen (9 percent) facilitating the 2014 MESA Day rated themselves in that category. In our experience, first-time ISTEM midshipmen tend to rate their leadership abilities lower on administered pre-surveys than experienced midshipmen facilitators. Furthermore, the data indicate that newer facilitators report greater gains in leadership abilities due to a single ISTEM event.

The November 5, 2014 MESA Day post-survey responses to *"What are two things you learned by participating in this STEM event?"* were coded and tabulated based on subject occurrence (Figure 5). One midshipmen wrote "I learned how to better communicate with children and how to lead groups of kids" (MESA Post-survey 2014). Therefore, this response was coded under communication, leadership, and audience (kids). Overall, responses mentioning working with children (26 percent), communication (22 percent), and facilitation experience (22 percent) occurred most frequently.

Midshipmen from all four events (Girls Day on October 19, 2013 and March 1, 2014; MESA Day on November 22, 2013 and November 5, 2014) rated their leadership abilities between 3.1 and 3.7 on post-surveys, with (3) being *Good Ability* and (4) being *Excellent Ability* (Figure 6). The highest skill averages occurred for ability to take charge of leading a student activity (3.6) and ability to teach a hands-on skill (3.6). Midshipmen facilitators are placed in the role of subject matter expert for each event and subsequently draw on their own STEM background to engage and lead participants. Prior training in event-specific project-based learning helps to prepare midshipmen as hands-on activity facilitators. The lowest skill averages occurred for ability to solve a conflict between participants (3.2) and ensuring participant satisfaction (3.3). This is possibly due to the nature of module execution. Children may be less inclined to argue in the presence of a stranger (the module facilitator). Moreover, module brevity (thirty to sixty minutes)

FIGURE 4. Percent positive increase in midshipmen self-evaluation of STEM leadership abilities for MESA Day on November 5, 2014.

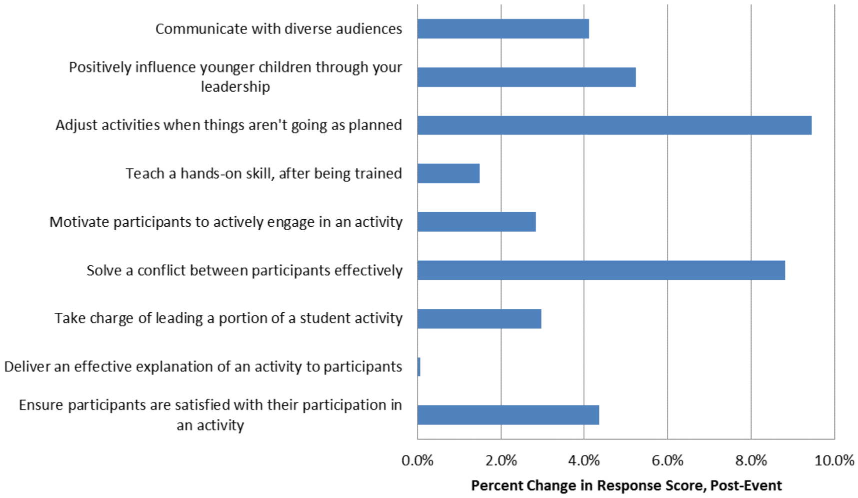


FIGURE 5. Occurrence of midshipmen open-ended response subjects regarding learning as a result of facilitating MESA Day on November 5, 2014.

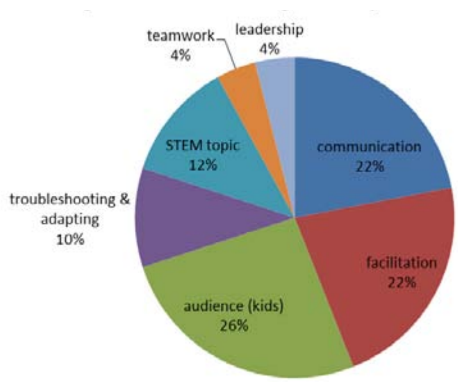
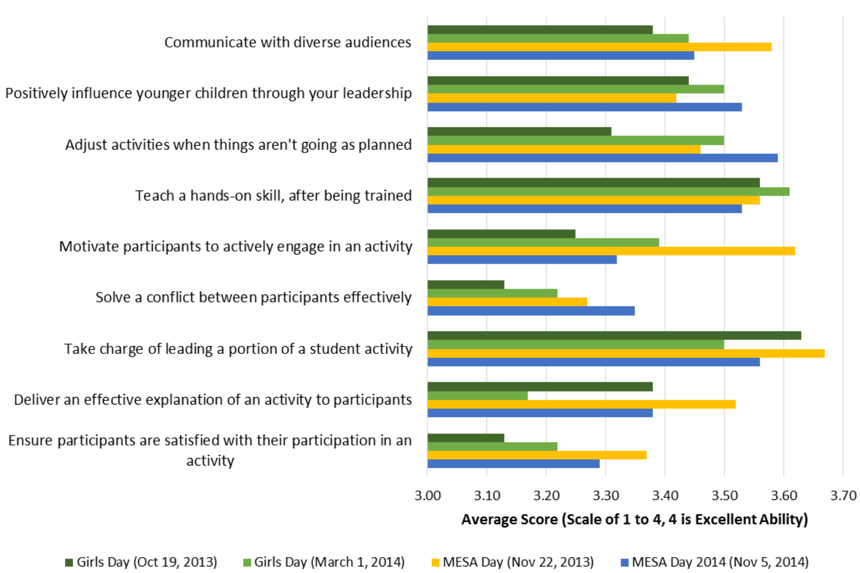


FIGURE 6. Comparison of 2013-2014 Girls Day and MESA Day midshipmen post-survey responses regarding STEM leadership abilities.



makes it difficult for midshipman facilitators to thoroughly assess participant satisfaction.

Comparison of post-survey midshipmen responses regarding effects of participation for all four events revealed overall gains in leadership skills, confidence to succeed in STEM, and understanding of a STEM field (Figure 7). The scores ranged between 3.8 and 4.6 with (3) being *Neutral*, (4) being *Agree*, and (5) being *Strongly Agree*. As a result of event participation, midshipmen indicated improved leadership skills (average = 4.4), more confidence in their ability to succeed (average = 4.2), and a better understanding of a STEM field (average = 4.0). A relatively weaker agreement occurred in response to *"this activity led me to a fuller exploration of my own career goals"* (average = 3.9). This may be due to the midshipmen's service commitment. Unlike traditional undergraduates, USNA midshipmen must serve at least five years in the Navy after graduation, making their career paths somewhat fixed.

STEM Impact Survey

General assessment of midshipmen ISTEM facilitators for the fall 2013 and 2014 semesters revealed gains in motivation to improve academic performance and to stay in a STEM major (Figure 8). Midshipmen also indicated a boost in confidence to succeed in a STEM field as a result of ISTEM participation, averaging 4.0 for 2013 and 4.2 for 2014 where (3) is *Neutral*, (4) is *Agree*, and (5) is *Strongly Agree*. As the following excerpts from the STEM Impact Survey 2014 show, open-ended responses support Likert question findings and also indicate gains in STEM application, communication, and enthusiasm:

> Response 1: "I had a better understanding of some of [my] courses by applying them in STEM activities. For example, I applied some knowledge about cryptography (that I learned in Plebe [freshman] Cyber) in one of the STEM activities I participated [in]!"

Response 2: "It seems simple, but the act of teaching younger kids about how cool STEM is actually makes me think about how interesting it actually is. It makes me more curious when I learn about the simple ways the world works and drives me to do research on my own."

Response 3: "Participating in a STEM outreach event helps me apply what I've learned in the classroom to a situation where I have to break down concepts in order to explain the science behind the math."

Response 4: "STEM outreach influenced me to stay within my STEM major because of how applicable it is to everyday life."

Response 5: "It makes me appreciate my major more. Being able to educate others in the basics of engineering is a great way to see how my efforts in school are benefiting others and their futures."

Many respondents indicated that facilitating ISTEM outreach influenced them to continue in a STEM major, thereby supporting our hypothesis that midshipmen's participation in ISTEM outreach improves their motivation to stay in the STEM pipeline. This is particularly interesting for policymakers and scholars interested in strengthening the metaphorical STEM pipeline in order to ensure future science and engineering talent for our nation's workforce.

Conclusion

The purpose of this study was to explore gains made by volunteer undergraduate STEM majors serving as ISTEM facilitators for USNA's STEM Center. Driving questions were (1) Do midshipmen demonstrate improvements in leadership, communication, and confidence after facilitating ISTEM events? and (2) Does participation in ISTEM improve midshipmen's motivation to continue in the STEM pipeline? We found that Girls Day facilitators experienced gains in their ability to motivate module participants, communicate with diverse audiences, and teach a hands-on activity. MESA Day facilitators reported gains in their ability to adjust activities spontaneously, solve conflict between participants effectively, positively influence children, and ensure participant satisfaction. Indeed, our findings correlate with existing literature that undergraduate facilitation of ISTEM yields improved confidence in discussing STEM concepts, greater communication skills, experience taking charge of an activity, practice improvising and adapting to the unexpected, and an improved understanding of STEM fields and their importance to society. Other STEM outreach programs might consider assessing gains made by educators, judges, mentors, or facilitators in a

FIGURE 7. Comparison of 2013-2014 Girls Day and MESA Day midshipmen post-survey responses regarding STEM event participation.

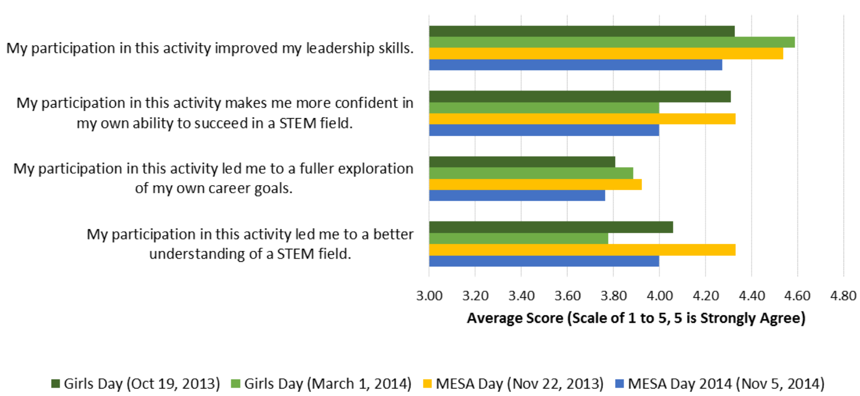
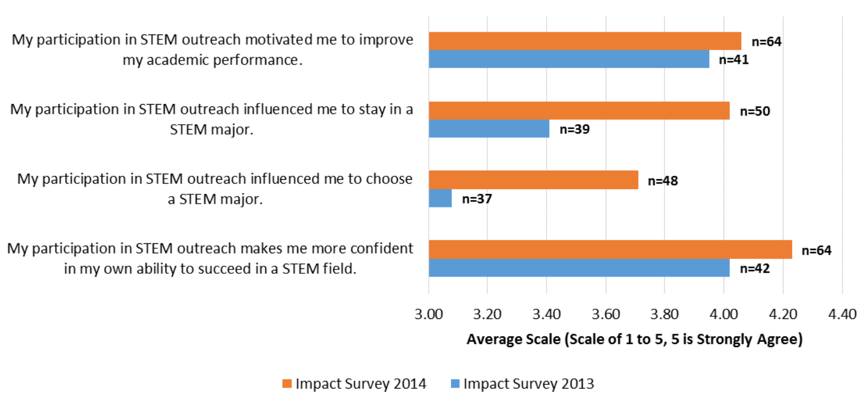


FIGURE 8. Midshipmen self-evaluation of ISTEM participation impact on academics for fall 2013 and 2014.



similar manner in order to better determine the impact of their event.

Furthermore, based on midshipmen's responses to the culminating STEM Impact Survey, experience facilitating ISTEM events appears to increase motivation to stay in the STEM pipeline and improve academically. This finding is significant for other outreach and education programs dedicated to improving retention in the STEM pipeline. Further research is needed to explore whether skills honed while facilitating ISTEM outreach help midshipmen after graduation—while serving in the fleet, or later, when some of them enter the civilian workforce.

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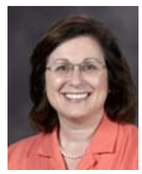

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PROJECT REPORT

Computer Science and Fairness: Integrating a Social Justice Perspective into an After-school Program

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Abstract

Children are motivated by the concepts of fairness and justice and by the idea that they can address problems in their communities and in the world. In this paper, we describe an after-school program that teaches Latino elementary school students how they can use computer science to address social justice issues at their school. The classes are co-run by high school near peers, who introduce both social justice and computer science concepts and guide students to design and program a final project. We describe both the process and outcomes of implementing this approach, including the challenges and opportunities, and the important role of the teacher and school context. The paper concludes with recommendations for efforts to engage elementary school students in computer science by scaffolding their awareness of social justice issues and involving near-peer role models.

Latino/as are the fastest growing ethnic minority population in the United States; they accounted for over half the growth of the U.S. population between 2000 and 2010 (U.S. Census 2010). Despite the growing numbers, Latino/as are vastly underrepresented in computing-related fields: in 2010, they made up only 4.6 percent of computer and information scientists in the labor force (National Science Foundation, 2014). Latinos are 16 percent of AP test takers, but only 1 percent of the AP Computer Science (CS) test takers; those who took it scored far below their peers (College Board 2011). Although Latinos make up 19 percent of all U.S. college students ages 18 to 24 (Lopez and Fry, 2013), the 2013 Taulbee Survey found they earned just 6 percent of CS bachelor's degrees, and fewer than 2 percent of students who enrolled or completed a Ph.D. in CS were Latino/a (Zweben and Bizot 2014). There are very few CS education efforts that target elementary school; most focus on high school or middle school students, even though early preparation is key to getting children on the pathway. In this paper, we describe a program that aims to engage children in

CS by having them explore and raise awareness about civic issues at their school.

The approach described in this paper builds on prior research that identified some promising strategies for recruiting students from underrepresented groups into computing fields. These include increasing access, relevance, role models, and experiences of success. For example, implementing a computer science curriculum that is relevant to students' lives both in and out of school is a strategy that has increased the participation of both girls and boys in CS courses. Students see that computer science is a tool they can use to solve real life problems (Ashcraft et al. 2012). In addition, having role models and near-peer mentors in CS courses can decrease the prevalence of stereotypes around computer science careers and increase interest in pursuing these types of careers (Craig et al. 2011; Lang et al. 2010). Opportunities to experience success are most effective when they focus on learning the material rather than completing a set of requirements in order to get a grade; this allows students with less experience to thrive and not feel disadvantaged compared to their more experienced classmates (Schwartz et al. 2009). Finally, students need access to learning opportunities that go beyond computer literacy (e.g. typing) in order to learn and apply CS concepts (Margolis 2008). A key part of this is teaching underserved youth to create technology, rather than merely using it (Denner and Martinez, in press).

A class that connects social justice to CS is a promising approach for computing education, particularly with Latino/a youth, because it shows the relevance of CS to what students value. For example, Latino/a students are more likely than other groups to say that the message "computing empowers you to do good" is very appealing (Association for Computing Machinery 2009). Doing good is connected to family obligation, and studies suggest that family needs (often financial) can serve as motivators for Latino/a students to pursue higher education and succeed on behalf of their families and communities (Cooper et al. 2005). For example, when asked about their career goal and why they wanted to pursue it, most Latino/a fifth grade students from a low income community described a helping profession (e.g., doctor, police officer), and said they want to help their community (Denner et al. 2005). When cultural value systems are taken into account, it appears that truly engaging Latino/a youth involves building connections to their identity and culture by also addressing the needs of their community, not just those of the individual (Sólorzano et al. 2005). In particular, exposure to role models and activities that show how CS can be used for the social good can increase students' expectations of success and the value they place on computing, which are directly related to their computing aspirations (Goode et al. 2006; Zarrett et al. 2006).

The program described in this paper was inspired by several movements that are focused on civic engagement. The first, Computing for the Social Good, aims to broaden participation in computing in higher education (Goldweber et al. 2011). For example, a growing number of colleges offer opportunities to apply CS to social causes, including Georgia Tech, Xavier University, SUNY Buffalo, and Rice University (Buckley et al. 2008). We extend this approach to K–12, adding perspectives from Latina/o critical race theory, an analytic tool used to critically examine how power relations shape Latinos' educational experiences by considering how race, social class, gender, language, and immigration status intersect (Yosso 2006). Using this lens, a class on social justice can help students identify issues they want to address in their lives, as well as the underlying or root causes of them, by learning about other young people who are making positive social change. The goal is for students to develop a belief that they can make a difference, or what some have called civic efficacy. Our application of Latino/a critical race theory to K–12 is informed by the Social Justice Youth Development model, which describes how social change begins with awareness, identity exploration, and a critique of existing structures before it moves to taking action to address social inequity (Ginwright and Cammarota 2002). In this view, critical consciousness is an essential part of social justice: it is not simply an awareness of an issue or problem, but is a critique of that problem that aims to identify the underlying causes, which include power dynamics in social relationships and institutional structures.

Our process for integrating social justice with CS builds on similar efforts in mathematics. Studies have shown the promise of using mathematics as a lens to introduce social justice concepts to Latino/a children, and to use social justice as a hook to teach mathematics (Gutstein 2003; Turner et al. 2009). However, we are aware of only three programs that aim to integrate social justice with computing: CompuGirls, an after-school program that links social justice concepts to the technical aspects of digital media (Scott et al. 2014), Apps for Social Justice, a class where youth learn to create apps that address local community needs (Vakil 2014), and Exploring Computer Science, a school-based curriculum that uses an equity-based pedagogy such as using data to make digital media artifacts about a social issue in their community (Ryoo et al. 2013). All of these programs were designed for high school students, and little is known about how a social justice approach can be used effectively to engage elementary school students in computing.

Studies do suggest that even young children are able to think about social justice, but pedagogical strategies must take into account developmental differences. For example, in one study of 6-17-year-olds in Argentina, children were asked to talk about something that had to do with justice that had either happened to them or that they had seen or heard about, and why they thought it was just or unjust (Barreiro, 2013). The researcher found that only 6 percent said they did not know what "just" meant. The most common representation of justice across the groups was utilitarian—justice is something that enables everyone to be happy. Only 5 percent of students referred to justice as an equal distribution for all people without privilege or bias, which includes concepts of fairness. Starting at age 10, students connected peoples' actions to whether or not they deserve punishment or reward. Similarly, Thorkildsen and White-McNulty (2002) found that children as young as six can consider the greater good when reasoning about fairness. However, that study also showed that children under 10 thought it was fair for people to win a skill-based contest as long as they worked hard, while according to older children, it was only fair for people to win based on skill, not based on hard work or luck.

There is little research on children's understanding of fairness at their school, which is the community they know best. One study found that 7-12-year-old children thought the most fair teaching practices were those that promote equality of learning (everyone should learn the same material equally well), but the emphasis on rewards for high performance declined with age (Thorkildsen and Schmahl 1997). In a more recent study of a small group of Latino/a fifth graders, the majority viewed random choice as the fairest way to make decisions, because it meant that everyone had the same opportunity and reduced favoritism, which suggests a view of procedural justice (Langhout et al. 2011). They also found that this group of children defined fairness in terms of equal outcomes (or distributive justice) and in terms of minimizing emotional harm (emotional justice). These studies show that elementary school students have opinions and even theories about fairness at their school, but few efforts have been made to help students explore or act on them. These studies also suggest that young children's ideas about fairness in the concrete examples of school and teaching are more developed than the abstract examples of fairness, and that few are ready to translate the concept of fairness into critical ideas about systems of power and social change. Based on this work, we concluded that the concept of fairness is more developmentally appropriate than "social justice" or "civic issues" when talking to young children.

While the studies described so far clearly show that children can think about fairness and have opinions about it, there is scant research on pedagogical strategies that can be used to build a critical consciousness about fairness in elementary school. In one report, Silva and Langhout (2011) describe how a first grade teacher used an art curriculum to increase her students' critical consciousness, with the result that many of the children took action to address stereotypes at school. The process included talking explicitly about power and privilege in terms of how group membership affected artists' lives and their art, and reflecting on emotions. In another example, Kohfeldt and Langhout (2011) describe how they helped a group of fifth grade students to define a social problem, which is the first step before taking action. Their approach included constructing the problem as a group, starting with a discussion of students' hopes and dreams about their school before moving on to discuss problems, causes, and potential solutions. The researchers used a series of questions to help students identify the underlying causes of the problem. These small studies suggest that teaching social justice principles in elementary school is possible, but despite the large number of educator groups devoted to teaching social justice principles (e.g., Rethinking Schools, Radical Math), there is little research on the challenges of integrating a social justice perspective into an elementary school classroom, or on how to connect social justice to academic content like CS.

The CSteach Program

CSteach is an after-school program based on prior research on how to engage underrepresented students in computing. It uses a culturally responsive approach that includes attention to students' multiple and intersecting identities, among them the students' identities in their school community (Scott et al. 2014). Key strategies include a multigenerational approach, the introduction of CS and social justice concepts, and the application of those concepts through the design and programming of a digital media project.

The multigenerational teaching strategy involves instruction and role modeling by high school aged near peers, students who are slightly older, more knowledgeable about the content area, and have qualities that younger students respect and admire (Murphey 1996). Near peers are not expected to be true experts; their value lies in being slightly more advanced, and also in being familiar with the community. The near peers (high school students) serve as role models and ensure that the program is responsive to the local context and to students' individual motivations, as well as to the dynamic role that culture plays as students negotiate their goals and obstacles (Brown and Cole 2002; Gutiérrez and Arzubiaga 2012). For example, the near peers understand local challenges (e.g., financial constraints, family responsibilities, etc.) and offer stories and activities that help students navigate competing expectations across their worlds of home, school, and peers (Cooper et al. 2005). The high school students also challenge negative stereotypes about who does CS, and provide examples of how CS can be used for the social good. The near peers in CSteach live in the community; in many cases they attended the same elementary school and/or have relatives who attend that school. They receive a stipend for attending trainings, reviewing the curriculum to practice their role, and for attending class.

A key goal of CSteach is to increase students' understanding of CS concepts and principles. A series of developmentally appropriate activities are designed to introduce and reinforce four of the College Board's (2014) seven "big ideas" in the Computer Science Principles: abstraction, algorithms, programming, and networks. These include learning to program in Scratch (a child-friendly drag-and-drop tool), doing unplugged activities where students write algorithms, and participating in online communities. The computer science activities are connected to four social justice "big ideas": fairness, empowerment, action, and community. For example, students explore how "networks" and "community" share similar properties. They also learn that "action" is part of the word "abstraction," and both involve moving from the general to the specific.

The CSteach curriculum builds on the Social Justice Youth Development model, where social change begins with awareness, identity exploration, and a critique of existing structures before it moves to taking action that will address social inequity (Ginwright and Cammarota 2002). Developing a critical consciousness is a key part of this effort: CSteach aims to help students go beyond a simple awareness of an issue or problem in their community. The activities in CSteach move students along the pathway from awareness toward action by showing them social justice role models in person and on video, encouraging them to debate what is fair and unfair at their school, introducing them to concepts like "bias," and helping them design and program an animated movie using the Scratch programming tool, to inform other people about why a particular social justice issue at their school is important.

Research Questions

This study was designed to document not only the outcomes, but also the process of developing and implementing the curriculum. In order to improve educational practice, it is necessary to go beyond a simple description of the implementation process to a description of what Gutiérrez and Penuel (2014) call the social life of interventions, or how they are adapted over time in response to the needs and strengths of students, teachers, and the broader school context. This involves bringing key people together to discuss and debate the primary focus of a research and development project. To this end, we employ a Design Experiment, an iterative cycle of implementation, data collection, and revision that helps us to develop programs that avoid a deficit perspective when promoting learning experiences for marginalized populations (Collins et al. 2004). The goal is to describe how to create a learning environment that utilizes social justice to promote students' interest in computer science, their capacity to productively engage in and apply social justice and computer science concepts, and the extent to which they see and appreciate the relevance of computer science. In this article, we will address the following questions:

- How did the social justice part of the curriculum evolve over time?
- How are fourth and fifth grade Latino/a students thinking about social justice?

- What are the challenges and opportunities of integrating social justice into an elementary school classroom?

Methods

Participants

CSteach has been implemented three times in a school district that serves mostly low income, rural Latino/a students, most of whom have family members who work in agriculture. Participants were 333 fourth and fifth grade students and 31 high school students who attended as part of an extended learning program at nine elementary schools. The mean age of the elementary students was 10, there were almost equal numbers of girls and boys, 85 percent self-identified as Latino/a, and 71 percent spoke a language other than English at home more than half the time. While there is great variation in the group of students called "Latino/a," the focus of this study is on students of Mexican origin, who make up 63 percent of the U.S. Latino population and accounted for three quarters of the growth in the U.S. Latino population in the last decade (Ennis et al. 2011). We use the term "Latino," because it is commonly used in California. The thirty-one high school near-peer teachers (mean age=15.5) were 61 percent female; 84 percent identified as Latino/a. Four adult teachers (all school district employees) were also interviewed (one male, three female).

Procedure

The CSteach course met for two hours/week for 12-13 weeks and was implemented over four semesters. Several sources of data were used to address our research questions. These included students' Scratch animation projects, classroom observations, interviews with high school students and adult teachers, and a survey administered to students at the beginning and end of the program. Student projects from the Fall 2013, Spring 2014, and Fall 2014 semesters were coded using a 0-3 scale to measure the extent to which students integrated a social justice issue into their Scratch animations. Each coding category was defined as follows:

Level 0: The project does not mention a social justice issue. Example: A cat and dog are on screen and the cat says it wants revenge. The dog says, "I have to get out of here," and the cat says, "You are not going to escape." The cat then attacks the dog.

Level 1: The project includes a complaint or a conversation about a social justice issue or a personal preference. Example: A bear is standing in the forest and a cat runs up and asks the bear to save him/her from the bully. The cat says, "Help hide me! The bully won't leave me alone," and the bear replies that he/she will "help get rid of the bully."

Level 2: Characters in the project advocate for something to change about a social justice issue or a personal preference, but there is no mention of why it is important. Example: A girl is sitting on a street corner near a man who is smoking. Two girls nearby see this and one says, "Look at that man smoking in front of that girl. Should we tell him to stop smoking?" The other girl replies, "I think we should," and then they ask the man if he can "please stop smoking" in front of the girl. The man thanks them for telling him to stop.

Level 3: Characters in the project advocate for something to change about a social justice issue and explain why it is important in a way that goes beyond personal like/dislike. Example: A boy in the library says that his "school would be better if there was a bigger library." Another boy appears and says that he "know[s] it is important because more students would be interested in reading and that would help with education." Then three more boys appear and reinforce the message by saying that students would "choose interesting books" to read, that "students learn by reading" and that "students would be more interested in going to the library."

Another source of data included a questionnaire that was administered on the first and last day the class. For example, students' views about the value of computing were measured with a six item scale from the National Assessment of Educational Progress (NAEP). Students rated their level of agreement with statements such as "Computers are important to my community," and "Learning about computers will help me in the future" (National Assessment Governing Board 2012). Students' views of how to address community needs were measured using a four-item scale that includes the following statements rated from Never to Often: "I know how to use a computer to identify needs in my community," and "Computer science is a field that makes the world a better place."

Over the three semesters, 21 high school students participated in either individual interviews or a focus group. Students were asked about their experience in the program and had the opportunity to provide feedback on their role. They were also asked specifically about the social justice component with questions that included: Tell me about a day this semester where the kids made the most progress in learning about social justice issues in their community. Tell me what could be improved in CSteach so that students will learn more about social justice issues in their community. Four adult teachers were also interviewed to gather information about their experience teaching the class, including what worked and what needed improvement.

Results

How Did the Social Justice Part of the Curriculum Evolve over Time?

The curriculum went through a series of iterations that were informed by both internal research and an external evaluation. In this section we describe some of the key stages of implementation, as well as the findings that led to a series of revisions designed to strengthen and increase the relevance and impact of the program and to increase the interest and capacity of the schools to sustain the class.

The first draft of the curriculum was pilot tested in two small classes during the Spring semester of 2013. In this initial version, the focus was primarily on teaching CS concepts, such as abstraction, algorithms, and data; there were only a few social justice-focused activities. An early attempt to integrate CS with social justice was an activity that introduced the connection between networks of computers and networks of people. However, additional follow-up and reinforcement of this idea was needed to help students use the concept of networks to address needs in their community. Another activity involved a role-play about a student-led effort to limit food waste at the school cafeteria. However, no connections were made to CS, and the focus was on food waste rather than the social justice issue of "hunger." As a result, students learned about the importance of helping others, but did not learn about the underlying causes of hunger. For their final project, students created a PowerPoint presentation based on internet research and data collection from classmates on a problem they want to solve in their community. Students were directed to select an abstract problem (e.g., bullying, animal cruelty) but the connection to the underlying causes or how the students could address them was not made. The students summarized their findings by adding them into a PowerPoint template.

Based on data that included observations, interviews, and an analysis of student projects, the curriculum was revised over the summer to reflect a stronger connection to the national K–12 CS standards (Computer Science Teachers Association 2011). This included teaching students to use the Scratch programming tool to make an animation where characters talk about a problem in their community. In order to help students select a social justice topic, we added a new activity where students learned about the CS concept "abstraction," and were instructed to apply it to their "problem" topic in order to break it into sub-problems that could be solved. However, the curriculum was not designed to help students think about the causes of the problem, and this limited the students' ability to break it into a smaller set of problems or to identify solutions. In addition, although the role of the high school near peers was strengthened by having them take the lead on instruction starting earlier in the semester and by training them in how to program in Scratch, they did not receive any training on social justice, and there was not a shared understanding of what the term meant. As a result, the topics in students' final projects were similar to those in the prior semester (e.g., bullying, pollution) and seemed to reflect adult concerns, rather than issues that were meaningful to the students. The new curriculum was implemented in Fall 2013 in four classes by two school-based teachers.

Based on classroom observations, interviews with near peers, and an assessment of students' projects, several changes were made before the Spring 2014 implementation. These included strengthening existing activities to make more explicit connections between computer science and social justice. For example, students learned how networks of computers and networks of people can both be powerful sources of social change. In addition, stronger connections were made between the final Scratch project and social justice. This involved showing examples and explaining how their animation would be created using the tools of computer science and then used to communicate a message about how to take action regarding a social justice issue. Although the high school student near peers were increasingly put in charge of leading large group activities, and received additional training in Scratch, they received no training in how to help students formulate a social justice issue. In addition, the connection to the regular class day was lost as the four classes in Spring 2014 were led by the same adult teacher who did the pilot implementation; a tech support employee of the school district with a CS degree. This change was made because the district was in the middle of contract negotiations which did not allow teachers to work outside the regular school day.

During the summer of 2014, the research team engaged in several activities in order to increase the relevance of the activities to the students and the schools. First, the team analyzed the data from observations, surveys, interviews, and the students' final projects. Next, there was a two-day meeting of multiple stakeholders that included two adult teachers, two high school-aged near peers, two experts in social justice, the project evaluator, and the research team. As a result of that meeting, we clarified the definition of social justice as something that a student believes is unfair and needs to be changed or improved. It should be relevant, and ideally personally meaningful to them. Further, it was agreed that the goals of the social justice component were to help students: (1) learn to identify and understand advocacy needs in their school and/or community, (2) learn how computer science can help address these needs (and how it could hurt), and (3) develop a sense of responsibility and motivation to use computer science to address those needs.

As a result of that meeting, the team identified social justice terms that were appropriate for elementary school students, more tightly integrated the social justice and CS principles, and added scaffolding to help students identify issues in their community that are personally meaningful to them. To this end, four "big ideas" of social justice were identified: fairness, community, empowerment, and action. These "big ideas" were designed to run parallel to the "big ideas" from Computer Science described earlier (College Board, 2014). The following are definitions of the social justice big ideas:

- Fairness: something in their community that they believe needs to be changed or improved. It is different from a complaint/dislike because it deals with whether there is inequality in people's opportunities, due to the distribution of wealth or other privileges.
- Community: the focus is on their school community, because it is personally meaningful to them and they can realistically expect to have an impact.
- Empowerment: the belief that they can make real change, and the motivation to do it; development of an identity as a leader or change agent.
- Action: collective action is the most effective way to have an impact; change happens by working with others and leveraging networks.

Several new activities were added to the curriculum for Fall 2014, in order to introduce students to these big ideas. The activities included a focus on student leaders, for example by showing short videos about youth who are taking action in their community, and an enhanced reflection component, a daily wrap-up where key CS and social justice concepts and terms were reviewed by a near peer, and then written down by the fifth grade students in their workbook. In addition, flexibility was built into the curriculum to accommodate students who arrive late or leave early due to other school activities or family commitments. In some cases, students worked with a partner who could catch them up and continue the project work in their absence. Another change was in the procedure for selecting and training the high school near peers, and expectations for their role in the classroom were clarified. Applicants were screened to ensure their commitment to working with children, as well as a positive attitude toward using computers and technology to help their community. As part of these revisions, the assessment process was also revised to improve our measurement of how learning progresses over time.

A final iteration of the curriculum was implemented in Spring 2015. The changes included teaching students the definition of social justice that is used in the Teaching Tolerance website: something that is free of prejudice, inequity, and bias. New activities were added to introduce and reinforce those concepts, using models from the website, such as "What is

Fair?" where students debate whether or not an issue (e.g., boys getting more time on the soccer field because they get there more quickly) is a social justice issue. A series of trainings were developed to scaffold the near peers' understanding of social justice, and to help them guide groups of students to narrow the focus of their final project so that it was about an issue that is personally meaningful to them at their school, rather than an issue in their broader community. The cultural relevance was increased by including bilingual Spanish/English instruction and worksheets, and videos of non-dominant groups taking action in their school and community. In addition, the CS learning part of the class was changed from large-group to self-paced instruction, as students learned to program in Scratch by watching videos created by the high school students, and then applying what they learned by completing a set of challenges. Finally, the role of the high school students became more diverse to allow them to use their strengths: some led activities with the whole class, while others facilitated small group activities or helped students who needed individual assistance.

How Are Fourth and Fifth Grade Latino/a Students Thinking about Social Justice?

Students who participated in the CSteach program varied in the extent to which they incorporated a social justice issue into their Scratch projects. From semester to semester, however, there was a steady increase in the percentage of students who used their Scratch animation as a tool to advocate for change. The Fall 2013 cohort produced only nine projects (21 percent) that mentioned a social justice issue (above a Level 0), while the Spring 2014 and Fall 2014 cohorts produced 15 (52 percent) and 45 (70 percent) projects, respectively, that scored above Level 0. Very few students (seven total) made projects at Level 3, where there was inclusion of information about why it was important to address the issue. The total number of projects that were scored in each category is summarized in Table 1. The data show an increase in the extent to which students integrated social justice into their Scratch project as the curriculum was revised.

TABLE 1. Social Justice Scores for Student Scratch Projects

	Level 0	Level 1	Level2	Level 3
Fall 2013 (n= 43)	34 (79%)	9 (21%)	0 (0%)	0 (0%)
Spring 2014 (n= 29)	14 (48%)	9 (31%)	4 (14%)	2 (7%)
Fall 2014 (n= 65)	20 (31%)	26 (40%)	14 (22%)	5 (8%)

Pre-post survey data were also used to understand how the children were thinking about social justice, including variation across demographic groups. Based on their responses to survey questions, fifth grade students from all semesters showed statistically significant increases in their perceived ability to use a computer or computer science to address community needs. However, this finding was less robust for certain subgroups. For example, students who frequently spoke a second language at home (more than half the time) were significantly less likely to make gains in this measure, and the gains were greatest during the Fall 2013 semester. Nevertheless, students demonstrated growth on that scale in every semester. Additionally, students made steady increases in the perceived value that they placed on computing, especially its importance to their community and daily lives. Table 2 provides a summary of these changes by semester.

TABLE 2. Pre-post Survey Changes in Social Justice Indicators by Semesters

	Ability to Address Community Needs	NAEP Value of Computing
Fall 2013 (n= 43)	+0.24*	-0.04
Spring 2014 (n= 29)	+0.13	+0.01
Fall 2014 (n= 65)	+0.14	+0.15

* p<.01

Although the survey results show that students moderately increased their perceived ability to use computers to address problems in their communities, they still struggled with connecting social justice issues to computing. Interviews with the adult teachers and the high school near peers provided some insight into how the fifth grade students were thinking. As stated by an adult teacher, Fall 2013: "I think that [tying social justice to computing] was hard for them just developmentally to do. That whole idea of the social justice topic and the community.... because it is something that I think is really important for the students to be aware of and I think that the students weren't generally interested in the topics that they chose but I just think it was hard for them to navigate and research and do all that on their own. They needed more guidance and help." This view was shared by the high school near peers, as shown in the following quotes:

> *Interviewer*: What do you think that they learned about using computers to address problems in their community?
>
> *Near peer:* I'm not sure, because we've only done that for the past three weeks and all of them picked bullying and pollution pretty much. I don't think maybe it's sunk in yet that we're talking about the community on the whole. Maybe they're thinking about just the schools. The fact that we're getting them to think about that even is, I think, pretty good.
>
> *Interviewer:* Do you think that's a new idea for many of them? That they could make a difference even at their school?
>
> *Near peer:* I would say so.

Another high school student described it this way: "We ask them: What are problems you see in your community? How are they supposed to know that? They focus on issues that they have at the house, like oh I have to go to bed at a certain time and I wish I didn't. Oh, I have too much homework at school. They're not thinking a larger bubble, which I understand. That's part of life that's all about them and what they're going through."

What Are the Challenges and Opportunities for Integrating Social Justice into an Elementary School Classroom?

The results suggest that although the fifth grade students were developmentally ready to identify a social justice issue and to explore the underlying causes, most needed additional scaffolding and support to integrate that understanding into their animation project. Challenges include having adult teachers and high school near peers who were unable to provide that support, and a school context in which some of the adults reinforced obedience to authority and discouraged students from questioning existing rules or procedures. The opportunities included connecting the social justice activities to existing civic education curriculum and leadership programs for students at the school.

A major challenge was in staffing the classes, which included limitations on the availability of both high school students and classroom teachers after school. It was also challenging to find adult and high school-aged teachers who were comfortable with both managing a fifth grade class, could learn and support the learning of others with computers, and were committed to following the curriculum and documenting what was changed and why.

In order to effectively run the classes, a teacher needs expertise in three areas: computer science, social justice, and classroom management. None of the four teachers in this study had all three. To address gaps in teachers' CS knowledge, we used existing resources that were developed and vetted by others (e.g., Hour of Code) and child-friendly software (Scratch). Given that the CS concepts were at an introductory level, the teachers who lacked the CS background learned along with the students, and relied on some of the high school-aged students who had experience with Scratch and some of the CS concepts. Filling gaps in teachers' experience with connecting computer science and social justice, or in their classroom management skills was more challenging, since both take years to develop and hone.

Most of the high school students also lacked one or more areas of expertise. Initially, few had the classroom management skills to lead an after-school fifth grade class, and many lacked the confidence or assertiveness to deal with disruptive or off-task behavior. While many were tech savvy, during their first semester they learned the CS concepts and their application in Scratch along with the fifth graders. None of the near peers had already developed the language associated with social justice, nor had they applied that lens to their own schools. However, quotes from their interviews suggested that as a result of their experience in CSteach, they learned how computers can be used to help the community or to make the world a better place.

> When [the adult teacher] was telling the little kids about networks and how a network of people is just like a network of computers, I was watching him give this speech, I felt like one of the students.

> I also realized that I was unaware about all this and I realized that these things that we usually use for fun can be used to connect to other people that we wouldn't usually connect to or connect to people that have been really hard to connect to. Kind of to try to change. I don't have any really specifics, but it was just sort of like a concept that was kind of beautiful.

The interviewer also asked "Did you learn anything about how computers can be used to make the world a better place?" And the student responded: "Yeah. Like make projects and show them out to people."

The empowerment aspect of social justice, which involved using the tools of computer science to create a product to advocate for change in the community, was a new idea and initially a difficult concept for them. At a training for the high school students in preparation for the Spring 2015 classes, the students were tasked with filling in the worksheets that would also be used with the fifth graders. At first, the students struggled to identify a social justice issue they wanted to address. Then slowly, examples emerged. One student described how the availability of food choices was unfair at her school. Her last class before lunch was across campus from the cafeteria, so she was often too late to get her first choice for lunch. She identified this as an injustice that affected her own and other students' nutrition. Examples from other students included the need for tutoring programs for students who are not adequately prepared for college; the need to raise money to make the playgrounds safer; the need for ramps and wheelchairs for special needs students; and the inconsistency of teacher enforcement of the school's policy about being late to class. However, while the high school students were able to identify some examples of unfairness at their schools, they were not clear about the underlying or structural causes for these issues or specific ways that these issues could be addressed.

The ways in which students engaged with social justice concepts must also be interpreted in the context of the schools they attend. In the early stages of the program, students did not differentiate between a complaint about their schools (e.g., recess is too short, video games and candy should be allowed) and a social justice issue (e.g., not enough books in the library that have stories about people who look like them). But by Spring 2015, when the social justice terms were defined and reviewed, students were able to explain why a certain issue was about injustice, prejudice, or bias. For example, they advocated for a swimming pool at school (for exercise and so that they could learn water safety), for pets on campus (for emotional support), for cell phones for students (for safety in the event of a fight), and for more science classes like chemistry (to prepare them for college).

However, despite the improvements in the curriculum and the increased understanding by the near peers of what social justice involved, the school context created other challenges. For example, students often arrived late to class or left early to do sports or drama; school-wide activities sometimes led to last-minute class cancellations; and some parents picked their child up early on their way home. Students who arrived late or left early often missed the important introduction and reflection activities. In addition, since the selection process varied across schools, students brought a range of prior experience and interest or ability to learn, and their level of commitment and attendance varied depending on why they were in the class. At some schools, students chose to take the course, while at other schools, they were assigned to take the course, either based on academic merit, or academic need. Schools also varied in the extent to which they required their students to have consistent attendance at the after-school program. Having to account for so many absences often disrupted the momentum of the class because there were always students who needed additional support to learn both the CS and social justice concepts from previous weeks. In addition, halfway through the Fall 2014 semester, daylight savings time ended. As a result, students at several schools left class half an hour early to walk home before dark. In these cases, students missed the review portion of class, which is when the social justice and CS concepts were reinforced.

There were several opportunities afforded by the school to help create a developmentally appropriate curriculum and pedagogy that was engaging, introduced and reinforced CS principles, and showed students that CS can be used to address needs in their community. For example, the curriculum was particularly effective when the teacher made connections between the social justice concepts introduced in CSteach and the activities and concepts students learned about during the regular school day. For example, during a session in mid-January on becoming a leader, the teacher talked about Martin Luther King Jr., whose birthday was being celebrated that week. The following are notes from that observation: "At the end of the class, for wrap-up, she talks about social justice in terms of MLK Jr. fighting for justice. She tells the class that she hopes they will find something that is as important to them in this class. She explains that we will be talking about social justice and helping them think about what it means here at our school." In another example, a near peer facilitating a discussion about leadership reminds a group of students that they already have a leadership program at their school where fifth grade students help younger children to solve problems. Connecting the CSteach activities to these familiar examples of leadership helped students to see the possibilities of using CS for the social good.

In summary, the data suggest that most of the elementary school students in CSteach were at the earliest stage of thinking about social justice issues (awareness). Challenges to integrating a social justice perspective into the class included the need to train the adult teachers and near peers so that they understood the definition and developmentally appropriate terminology associated with teaching children about inequity. Additional challenges to connecting social justice to CS include the limited time in which to introduce, reinforce, and apply the social justice concepts, and to teach children how to program well enough to express their ideas in Scratch.

Discussion

In order to increase diversity in computer science, it is important to help children see the relevance and the value of the field for issues that are meaningful to them. The CSteach program described in this study is part of a larger effort to engage young people by showing them how computing can be used for the social good. In this paper, we describe the evolution of a social justice curriculum, including the challenges and opportunities of integrating it into an elementary school-based after-school class, as well as connecting it to computer science. We report on both the strategies and the results of this program, using data from student projects, classroom observations, interviews, and surveys.

The findings from this study contribute to research on how fifth grade Latino/a students are thinking about social justice. Their Scratch animation projects, as well as interviews with the high school students and adult teachers, suggest that participation in the class led to an increased awareness of the difference between a complaint and social justice issue. This was shown in the ability of most students to identify something at their school that needed improvement, although the topics focused mostly on safety issues, which are a common focus of school assemblies. Only a small number used their project to advocate for change or to explain why the issue was important. While this finding may be explained in part by a lack of programming skills to express that knowledge in their projects, our observations of and interviews with the high school students and adult teachers, as well as our efforts to ask students about their projects, suggested that most did not see themselves as leaders who can make change, did not understand the underlying causes of the problem, and could not identify ways to take action. The finding is consistent with another study of fifth grade students in a mostly Latino/a community, which also found that few students identified the underlying causes of the problems at their school (Kohfeldt and Langhout 2012), and studies outside the U.S. (Barreiro 2013; Thorkildsen and White-McNulty 2002) that find most elementary school children to be at the early stages of the Social Justice Youth Development Model, which begins with awareness and moves to identity exploration (Ginwright and Cammarota 2002).

This paper also describes the challenges and opportunities of integrating social justice into an elementary school classroom. Based on several iterations of implementation and data collection, the final curriculum uses a scaffolding process that starts with increasing the students' awareness about social justice issues and developing their identity as leaders, with support from near peers who live in their community. Like Kohfeldt and Langhout (2012), we found it was important to begin a social justice conversation by talking to the children about how to make their school a better place, rather than asking them to identify problems or concerns. Focusing on improvement was one strategy to prevent students from taking a deficit perspective about their school; instead students were encouraged to focus on how they want their school to be, rather than on the problems. Both feedback and reflection played a critical role in helping children to think about the connection between CS and social justice, which is a strategy that has also been successful with high school students (Scott et al. 2014).

One of the challenges was to help students develop a critical eye toward phenomena they see every day, a challenge that Gutstein (2009) also describes in his social justice mathematics classes. An effective strategy is to start by talking about an issue they identify as "unfair," and then ask questions that move students from voicing a complaint to an understanding of the structural reasons for that issue. In CSteach, there was not always enough time or enough experienced educators to move the students deeply into an issue. One promising strategy was for students to work in small groups led by trained near peers; the interaction increased the opportunity for students to internalize the information and make it more personally relevant. However, as Scott et al. (2104) explain, culturally responsive teaching requires instructors to reflect on their own identities and cultural backgrounds, and most of the high school near peers had not yet developed their own language or critical consciousness about issues of inequity and fairness.

An important challenge was finding teachers with the range of knowledge required, who were comfortable teaching computer science concepts, guiding students through a process of identifying a social justice, and managing the behavior of fifth graders in an after-school setting. Gutstein (2009) laments that few teachers have the time or expertise to build among their students a critical consciousness and an identity as change agents, and that some may see it as outside their role. Again, it might be more important to select teachers for this type of orientation than for a CS background. Key elements for success include having classroom teachers who develop strong connections to what students are learning during the school day, and high school near peers who have (or build) a critical consciousness about injustice at their school, as well as an identity as a social change agent.

Children now have access to a growing number of digital media tools, but how and for what purpose they are used varies depending on the interest and expertise of the adults in their lives. In this paper, we describe an effort to leverage children's interest in "fairness" in order to introduce them to new computing skills and concepts and to build their interest and capacity to use computers to create social change. Rather than just documenting the "success" or "impact" of the CSteach program, we included a description of the steps and the challenges involved in developing, implementing, and studying a curriculum that connects computing with the social good. The findings provide insight into the process through which children develop a social justice orientation and learn computer science concepts, and the conditions under which these can mutually reinforce each other. However, several supports need to be in place to move students beyond awareness and empowerment to a sense of identity as a change agent and to an understanding of the power relations and institutional structures that perpetuate inequity. Key supports include teachers who have training in social justice education with young children, access to computing tools and resources, the involvement of tech-savvy and socially aware near peers who live in the local community, and clear connections between the larger school context and what children are learning about computer science and social justice.

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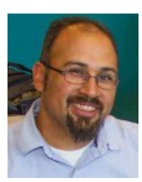

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PROJECT REPORT

How We Engaged Audiences in Informal Science Education through the Inaugural Arkansas Science Festival

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Abstract

Science festivals are gaining popularity as informal science education (ISE) events. With support from the Science Festival Alliance and Arkansas State University (A-State), we launched the inaugural Arkansas Science Festival in October 2014. Few science festivals are held in rural areas such as the upper Mississippi Delta, A-State's home, so challenges were expected. Our local and campus communities enthusiastically came together to host events over eight consecutive days. Beginning with school groups attending the opening performance of ArcAttack's singing Tesla coils, through the Science Expo's dozens of hands-on activities, displays and performances, and events in between, we attracted over 2000 participants to our festival. Here we describe the challenges and successes of the first ever Arkansas Science Festival, and how even with a limited budget in a rural setting, we engaged participants in ISE activities.

ISE through the Arkansas Science Festival

Informal science education (ISE) experiences can spark new interest in STEM (science, technology, engineering, and mathematics) fields (National Research Council [NRC] 2009). As advances in the domains of science and technology impact all areas of life, the importance of developing a scientifically engaged public in the 21st century cannot be overstated. One type of ISE experience, the science festival, has become a popular event across the United States and abroad. Though highly varied, science festivals typically focus on a celebration of STEM by engaging the public with scientific content (Bultitude et al. 2011). Science festivals may be offered in a single day or across multiple days, and in a variety of community, university, and museum settings. Each of the 40 science festivals established over the past five years has its own identity, but all rely on STEM practitioners to bring science to participants in an informal, interactive format (Wiehe 2014).

The authors of this paper, research scientists at Arkansas State University (A-State) with interests in ISE,

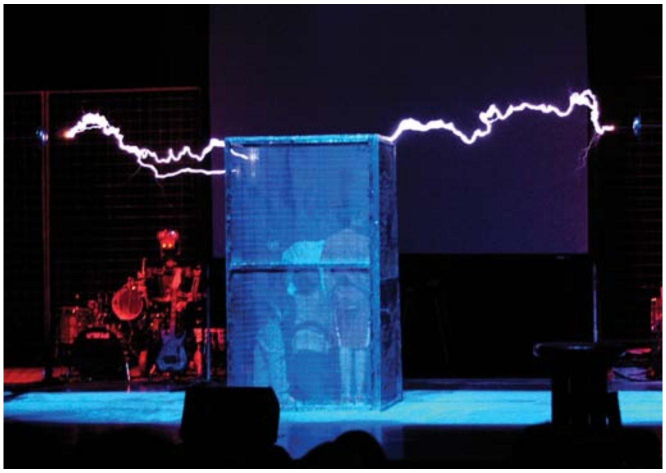

FIGURE 1. ArkSciFest attendees in the Faraday Cage at ArcAttack

implemented the state's and region's first science festival in Fall 2014. At the time of planning, approximately 50 science festivals were listed on the Science Festival Alliance website, yet none was listed in the rural South. Scientific literacy is important for all; however, inhabitants of rural communities seldom have opportunities to engage in ISE activities. Our targeted region was the upper Mississippi Delta, which has some of the lowest population densities in the southern U.S. This economically poor region has a historically agricultural focus, little STEM industry, and some of the lowest levels of higher education in the country. The 2014 state data tool of the National Science Board revealed that only 13.8 percent of Arkansans hold bachelor's degrees, while fewer than 9.2 percent of the residents of the Delta region of Arkansas have a bachelor's degree (NSB 2014), one of the lowest rankings in the country. Comparable results are found in other states in our recruitment region. Our immediate region, the Jonesboro, Arkansas area, with almost 72,000 people, has a fairly diverse population, approximately 71 percent Caucasian, 18 percent Black, and 6 percent Hispanic (Cubit Planning 2015). Median household income in 2013 was approximately $39,000, with more than 25 percent of city residents living in poverty (Cubit Planning 2015).

To build the first Arkansas Science Festival, we sought funding through an initiative from the Alfred P. Sloan Foundation managed through the Science Festival Alliance, a group whose mission is to help create more and better science festivals. On our campus, the Colleges of Education and Behavioral Science, Sciences and Mathematics, and the Arkansas Biosciences Institute provided internal matching funds. Through these generous entities, we had an initial total budget of $20K. Using a preliminary A-State activity schedule, we set a date for our festival in collaboration with the performing arts center on our campus and secured a science-themed musical group, ArcAttack, folding their performances into an established family-friendly concert series. Our other activities were planned to span the weekend of that date, and we would use the ArcAttack performances on the first Friday of October 2014 to attract area students and their families back to campus for the Science Expo the following day.

Issues

Our first setback occurred shortly after finalizing the date for ArcAttack: we could not schedule campus activities the following day, as homecoming, a major athletic event for our university, was now planned for that date. Making "lemonade from lemons," we decided to participate in homecoming by securing a tailgate tent to host activities and promote other science festival events, which would now span eight consecutive days, culminating in the Science Expo the following Saturday. Another issue was that we needed to secure university approval for a logo design and promotional materials through our Office of Marketing and Communications, which we found to be a very busy office. Additionally, there were difficulties in clearing university protocol when soliciting community members for their financial support and inviting outside entities to join in the celebration. This "red tape" caused us to lag behind in both promotion and fundraising for our festival.

Back on Track

With our first two events secured, we sought collaborators within our community and across the state. The county public library offered to sponsor an activity during festival week, and also agreed to participate in the Science Expo. The organizer of a long-running science café in Little Rock (140 miles away) assisted us in hosting the first science café in our region for the festival. We secured an award-winning Arkansas author and radiologic technologist to present a talk on Marie Curie at the Expo, as well as community music groups to present at our homecoming tent. The Arkansas Museum of Discovery (also from Little Rock) arranged to bring their mobile science museum to be enjoyed by student groups on opening day.

Campus Collaborations

We found many enthusiastic campus collaborators and colleagues. The Arkansas State University Museum planned "warm up" activities for visiting regional students prior to the morning ArcAttack performance, as did staff from the Rural and Delta STEM Education Centers on campus. A professor of theatre suggested "Playing with Science," a national playwriting contest for short science plays. A rock band comprised of faculty and students agreed to perform at the Expo, and several individual faculty, graduate students, and student groups began organizing activities to be presented at the Expo and in the homecoming tailgate tent. Many of the student organizations affiliated with the College of Sciences and Mathematics received guidance from the Student Club Coordinator, who is also currently working on a project of civic engagement sponsored through a SENCER SSI Implementation grant. One of the authors (KY) organized a research methodology course in which undergraduate students designed field studies to be conducted at the various activities. Further, a strategic communications team adopted the science festival as a class project; these undergraduate students organized and planned promotional strategies, and one interned part-time during the summer to help launch our website, Facebook page, and other promotions. Local media, including our campus NPR station, local television station, and newspaper, announced activities, and ran interviews, ads, and articles.

FIGURE 2. ArkSciFest attendees launch a weather balloon to bagpipes.

FIGURE 3. Checking out the ELF, a solar-powered tricycle.

Festival Week

The "Singing Tesla Coils" of ArcAttack kicked off the festival with a daytime school-based show, followed by an evening show for the public. Together, the two programs brought in over 1,100 children and adults. The next day's Homecoming Science Tailgate Tent presented the launch of weather balloons to the sound of bagpipes, solar-cooked hotdogs, beer-goggle Baggo, juggling, marine touch tanks, and an entomology collection. This event involved more than 250 attendees and volunteers and reached a large cross section of the community, and we had a welcome visit by a mentor from the Science Festival Alliance. Other events included the astronomy-themed science café held at a local restaurant, a tinkering studio in the A-State museum, a unique mindfulness and biofeedback workshop, and a science of music event at the county public library. Another standout program was "Playing with Science"; over seventy-five original short science plays had been submitted by local, national, and international playwrights (some of them award winners). This fusion of science and the arts was brought to life through readings of the finalists in the playwriting contest by both scientists and actors. The festival closed with the Science Expo which featured over twenty-five activity stations and events and attracted approximately five hundred participants. The total cost of the eight-day festival was under $10,000, which was used for promotion, supplies, and the paid performances of ArcAttack. All labor was done by volunteers,

FIGURE 4. ArkSciFest Playing with Science Short Play Experiment.

including faculty, staff, and students from A-State, as well as community members and museum staff. We estimate that approximately 125 volunteers spent a total of 500 hours in planning and carrying out all the events held over the eight days of the Festival.

Several Goals Attained!

With the financial support of the Alfred P. Sloan Foundation, mentorship from the Science Festival Alliance, and the support of the many volunteers, Expo hosts, event hosts, student and community organizations, speakers, and performers, we reached our goal of bringing science, technology, engineering, math, and health professions to over 2,000 people in our community (from Jonesboro's population of about 72,000) in exciting and educational formats. Due largely to our volunteers' generous assistance, we spent less than half of our initial budget, enabling us to maintain some funding toward the 2015 Arkansas Science Festival.

Attendees were asked to provide feedback regarding their experiences by completing a brief survey given by student volunteers (Table 1) who were stationed outside the exit doors of the Expo. Sixty-nine adult attendees completed the survey (66 percent female; M age = 37 years, range = 18 to 67 years; 83 percent Caucasian, 3 percent African-American, 3 percent Asian, 2 percent Hispanic; 8 percent selected "other" or multiple categories). We estimate this was approximately 14 percent of all attendees, both children and adults. Since attendance was measured simply by the number of people entering the hall and was not broken down by age, it is impossible to tell what percentage of the adult attendees completed the survey, a limitation of this research. However, 62 percent of the adults who completed surveys indicated they had brought children with them; thus, we theorize that we have captured a higher proportion than 14 percent of the adult population who attended the Expo.

Items were designed to assess perceptions of different aspects of the event, and three different forms were utilized. All participants were first asked why they attended the event. Then all participants were asked to rate the event on a five point scale (5 = excellent, 1 = poor). A series of statements were then given to all participants to assess impact on interest/learning, such as "Now I'm more interested in STEM than I was before coming today," affective reactions such as "I enjoyed myself at this event—it was fun," and impact on engagement, such as "I totally got into what I was seeing or doing at the event; I was really engaged in what I was doing." Participants responded to these using a Likert-type scale (5 = strongly agree). The remaining items varied depending on which form participants received. This paper focuses on the items that all participants received.

Participants had a wide variety of reasons for attending the Expo. The most common response (40 percent) focused on attending because of children or grandchildren. Means for all items were significantly higher than the neutral point, $p < .001$. Twenty percent mentioned they enjoyed science or were interested in learning more about science or the exhibits, and 11 percent believed the event would be fun. (Note: participants' responses could fall into more than one category.) Results revealed that participants rated the result quite highly, $M = 4.4$, $SD = 0.6$. A one-sample t-test revealed this was significantly higher than the midpoint of the scale (which was labeled as "good"), $t(68) = 19.5$, $p < .001$. Finally, participants' responses to individual survey items (see Table 1) also reveal that participants reported positive effects in learning STEM content, were engaged in the activities, and had positive affective responses. Again, a one-sample t-test revealed all means significantly higher than the neutral midpoint of the scale, $p < .001$. Perhaps most tellingly, the most highly rated item was agreement that attendees would be interested in attending another science festival. No significant correlation was found between age and any of the items, and no differences were found as a function of gender.

TABLE 1. Adults' Ratings of the ArkSciFest's Science Expo (Mean and Standard Deviation)

Item	M (SD)
I would like to attend another science festival.	4.7 (0.5)
I enjoyed myself at this event—it was fun.	4.6 (0.5)
I enjoyed the booths and displays at the science festival.	4.5 (0.6)

Note: all $p < .001$, compared to the neutral point of the scale

Discussion of Results

Overall, research and evaluation in ISE has lagged behind program development (Bultitude et al. 2011; Hussar et al. 2008). Manning, Lin, King, and Goodman (2013) released one of the first assessments on science festivals. Manning surveyed participants at several major science festivals (all held in urban areas, such as San Diego, San Francisco, and Philadelphia), and results revealed that 78 percent reported that science learning was more fun and enjoyable as a result of attending the events and that 79 percent claimed they would "look for information on something they had learned at the festival." From our Expo, 66 participants who had attended a science event the prior year reported actually having engaged in behavior to search for more information on a topic, an indication of increased engagement in science. The results from the present study augment the limited research by providing evidence that a more rural population may also derive benefits from these types of informal science activities.

Next Steps

New partnerships were formed between festival organizers and the county library, local museum, and university performance hall, all of which have committed to continue in future years of the festival. Finalists of "Playing with Science" have been selected for publication in an anthology to be disseminated to other festivals and schools. Plans are currently underway for the next Arkansas Science Festival to be hosted in October 2015, and we have partnered with the NSF-sponsored EvalFest team to evaluate it. To continue the growth of the festival we intend to form a steering committee as well as an advisory board, and we welcome the Museum of Discovery, Little Rock, and EcoFest, Conway, Arkansas, which have committed to being a part of the second Arkansas Science festival, expanding the festival beyond the Northeast Arkansas region.

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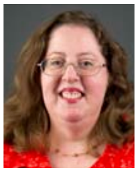

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PROJECT REPORT

Sustaining Place, Language, and Culture Together

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Abstract

Our initiative involves a community engagement partnership guided by an understanding of decolonizing methodologies and an overarching goal to sustain the place, language, and culture of the Alaska Native village, Chevak. Furthermore, the Indigenous sovereignty and ownership of ancestral ways of knowing guided the design and implementation of this initiative. The Will of the Ancestors is an ongoing effort that involves a rural, community-based partnership of Elders, Indigenous inservice and preservice teachers, parents, and elementary students from a rural community located near the Arctic Circle and an education faculty from a major state university in Alaska. This synergistic approach includes the following components: teacher education, a collaborative Science, Technology, Engineering, Arts, and Mathematics (STEAM) curriculum project, the creation of a local atlas of plants and animals important to subsistence, and language revitalization through a children's book project and writing workshop.

Introduction

The Native American Languages Act, Title I of Public Law 101-477 proclaims: "The status of the cultures and languages of Native Americans is unique and the United States has the responsibility to act together with Native Americans to ensure the survival of these unique cultures and languages." Additionally, Congress made it the policy of the United States to "preserve, protect, and promote the rights and freedom of Native Americans to use, practice, and develop Native

American languages." Adding to the discourse, in April of 2014, the President of the National Alliance to Save Native Languages provided testimony to the U.S. House of Representatives on the need to support programs that help meet the linguistically unique educational needs of Native students while also preserving, revitalizing, and using these students' native languages (Testimony of Ryan Wilson 2014).

While the charge is clear, so are the reasons behind it. In their work, Angelina Castagno and Brian Brayboy (2008) point out that the rhetoric that recognizes the shortfalls of the K–12 educational system offered to Indigenous students in this country dates back almost fifty years. At 13.2 percent, the dropout rate for Indigenous students is among the highest of any ethnic group in the United States (Aud et al. 2011). The statistics regarding the academic achievement of Native populations, particularly Alaska Native students enrolled in K–12 classrooms, indicate a persistent gap in achievement (also referred to as the "opportunity gap"). Often these system inadequacies are aggravated by the high teacher turnover rate. According to the University of Alaska Center for Educational Policy and Research, the teacher turnover rate in rural areas has been reported to average 20 percent, with some rural districts reporting a teacher attrition rate as high as 54 percent. One of the factors contributing to this rate is the teachers' lack of knowledge about the local culture and traditions (Hill and Hirshberg, 2013). Additionally, the amount of material available to these students in their native languages is abysmal. This is important given that the number of books in the child's home and the frequency with which the child reads for fun are also related to higher test scores, as reported by the National Assessment of Educational Progress (NAEP) (National Center for Educational Statistics 2013).

While there is no denying the discourse centered on the failures and inequities of the past, this project was initiated to provide a more thoughtful, action-driven, and synergistic approach. Our approach seeks to address the needs of K–20 students and their teachers, while preserving the Alaska Native cultures, languages, and subsistence ways of life. To do that, we have embarked on several projects, including the following components: a teacher education plan, a collaborative Science, Technology, Engineering, Arts, and Mathematics (STEAM) curriculum project, the creation of a local atlas of plants and animals important to subsistence, and language revitalization through a children's book project and writing workshop.

Theoretical Understandings of Our Work

The community engagement projects have their foundation in the possibility and hope that through authentic engagement, students and faculty can establish meaningful relationships and a genuine appreciation of the importance of language, culture, and place with members of an Alaska Native community. Thus, this project was approached and implemented using two theoretical lenses: (1) Sociocultural Theory applied to science education (Tobin 2013) as a means of improving practice through research that benefits the participants; and (2) Demmert and Towner's (2003) "culturally based education" (CBE), which emphasizes the following elements: recognition and use of Native languages; pedagogy using traditional cultural characteristics; teaching strategies and curriculum congruent with traditional culture and traditional ways of knowing; strong Native community participation in education; and knowledge and use of the political mores of the community.

Setting the Context: Life in the Arctic Circle

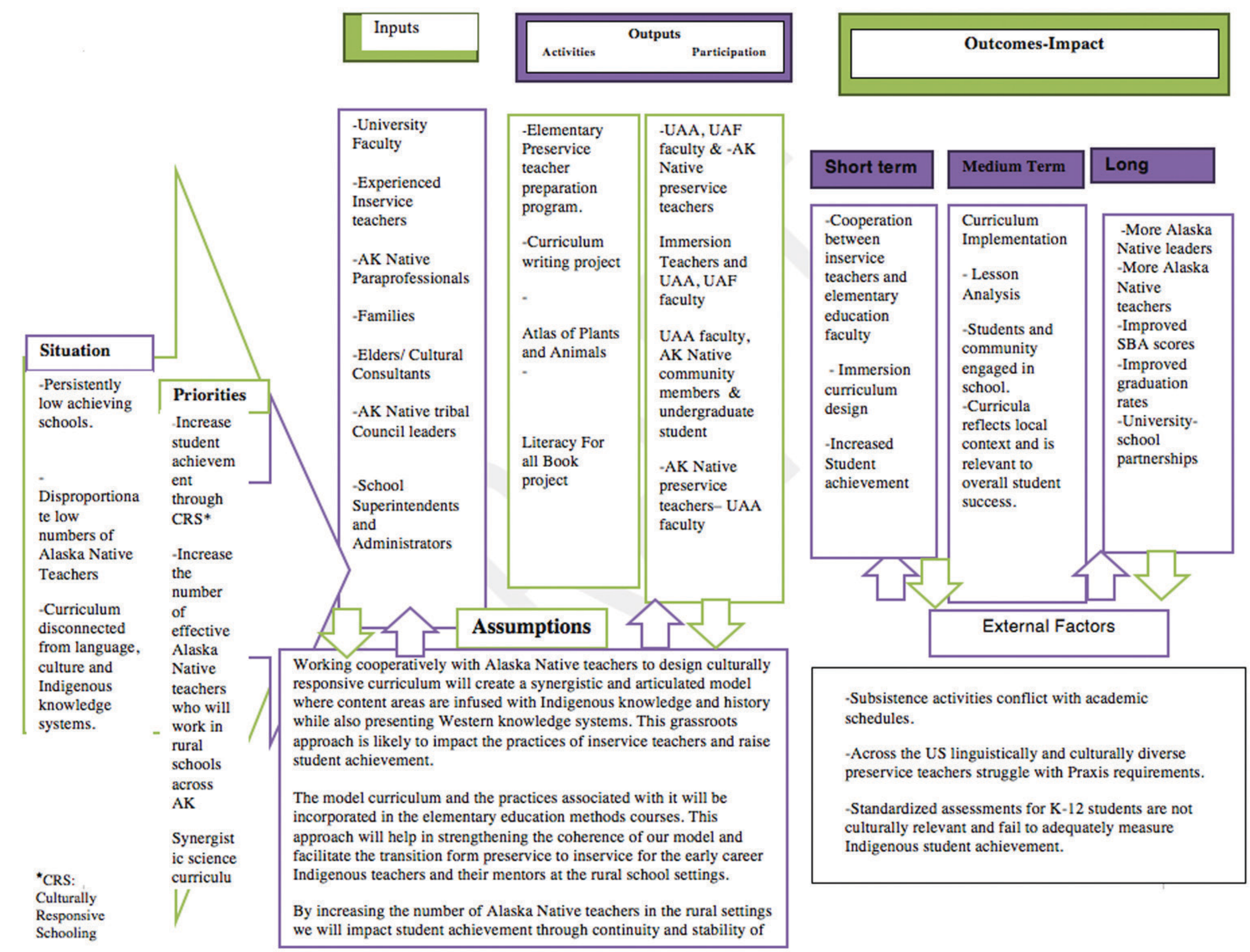
For thousands of years the Arctic tundra and the nearby Bering Sea and its tributaries have provided shelter and endowed the inhabitants of this remote village with an environment that has supported rich cultural traditions rooted in ecologically responsive knowledge and subsistence living in rural Alaska. Ancestral knowledge dating back thousands of years has been shared through oral traditions of storytelling, songs, and dances. Subsistence gathering and hunting are carried out using principles of harmonious coexistence in one of the harshest environments on Earth. The careful gathering of eggs and berries, ice fishing in the winter, spring seal hunting, and summer fish camps have ensured the survival of the Cup'ik people for thousands of years.

The bicultural, bilingual community of Chevak, Alaska is faced with language retention issues and with the challenges associated with incorporating Western technology while still maintaining a strong cultural identity, culture, and language. The Elders, teachers, and preservice teachers who work in the Immersion program are fluent and literate in their native language and possess anecdotal and practical knowledge of subsistence activities and ways of knowing in science. On the other hand, many of the parents of school-age children do not participate in subsistence activities and/or struggle with the Cup'ik language.

Multiple Approaches to Language and Culture Revitalization

Our involvement with this community engagement project began in 2010 when the superintendent of the Alaska Native community of Chevak approached the College of Education faculty about the revolving door of teachers in his district. Every year, teachers from outside Alaska came to teach at the school and very few lasted more than a couple of years. In extreme cases they did not return after the winter break, leaving children without a certified classroom teacher for months at a time. The request the superintendent made was for our college to provide a quality preservice education program for the Alaska Native paraprofessionals at the school. These individuals have deep roots in the community. Many even have relatives who graduated from the school or children who are enrolled in the K–12 school. This request began a collaboration between the faculty at our college and community members from the village. The Alaska Native paraprofessional initiative inspired faculty members to continue and deepen their collaboration with Elders, teachers, parents, and students. Five years later, these community-engaged projects are all intricately connected and mutually informing. The

FIGURE 1. Logic Model



design and implementation of each initiative emerged from thoughtful conversations between community members and faculty. The initiatives include: (1) Alaska Native teacher preparation project; (2) Traditional ways of knowing in the STEAM curriculum; (3) Local atlas of plants and animals; (4) Children's book project; (5) Writers group. Although we describe them below as separate projects, they are, in fact, a part of an integrated approach that has emerged through our collaboration. The graphic representation below shows how each project is linked within the partnership, followed by a more detailed description.

The Alaska Native Teacher Preparation Program

The Alaska Native teacher preparation initiative seeks to prepare teachers who are fluent speakers of Cup'ik and who can serve the cultural, academic, and linguistic needs of students in the K–6 Language Immersion Wing, as well as in the English Language Wing. As the president of the local school board stated,

> *The members of the cohort will teach in the immersion program. We want to produce homegrown teachers with the help of the university. We support this program and would like to see it expand in the years to come. The presence of the faculty in our village is really appreciated. The cohort is taking the Western-style approach and the cultural roots of our people and merging them side by side, in the way Elder Boyscout envisioned it. This program will benefit our people, our kids. It is a model that other villages can follow.* (Jeff Acharian, School Board President, April 12, 2013)

This model is a cohort model, enrolling currently uncertified Alaska Native paraprofessionals, who are already working in the classroom, in the elementary education program at the University of Alaska Anchorage. The cohort has ranged in number from twenty to seven, depending on the semester, starting in 2010. While the students take many of the classes via distance learning, which allows the students to continue to work at Chevak School, take care of their families, and practice subsistence, intensive courses have also been offered on site. These intensives are run over the course of one week and allow the cohort to experience an active learning environment while also cultivating relationships with a variety of university faculty, including those in the elementary education program, early childhood education program, and College of Arts and Sciences (for example science, philosophy, and anthropology faculty).

Although both faculty and cohort members generally prefer face-to-face classes, it is not economically feasible to fly instructors to the village for every class. In the beginning, more classes were offered on site, but as students have gained access to technology and the Internet, they have participated in more online courses. Intensive courses scheduled around subsistence are offered when possible (depending on faculty availability and funds).

During a session at the 2013 Alaska Native Studies Conference, a panel that featured members of the teacher preparation cohort, school board members, and university faculty shared their engagement with the project and its importance to the people in the community. The panel opened with the voice of cohort member Susie Friday-Tall, who shared the story of turning driftwood.

> *My mother shared the story of the driftwood with me; she heard it from my grandmother: The driftwood is alive and it deserves to be turned over. The pieces of driftwood talk. Each one says something different: I will be a harpoon, I will be a boat, I will be a walking stick. The driftwood will become something useful. We have to turn it, to make it useful. … My dream is to see our local people become teachers from kindergarten to 12.* (Susie Friday-Tall, cohort member)

This story exemplifies the partnership that started five years ago, which seeks to provide a culturally sustaining teacher preparation program. The paraprofessionals who are part of the preservice teacher cohort have been working at the school for over a decade. One cohort member shared:

> *[With] the support I received from the teacher initiative I have been able to take college classes. This is a dream that I thought was so unattainable that it would die. Thanks to this initiative I will someday reach the goal to become a teacher for our Cup'ik children.* (Cikigaq Joseph, cohort member, March 12, 2012)

Yet another young woman shared in a spirited voice what the program meant to her:

When we all reach our goals of becoming teachers it is going to be amazing. We know our students, we live among them; we eat the same food. I know that when we teach them they will soak up the information. Our children will excel. I am really thankful to this program. We are going to keep going and the students are going to fly; they are going to be good. (Julia Alberts, cohort member, April 12, 2013)

Finally, university faculty have also attested to the importance of this work and what they have received in return. As Assistant Professor of Early Childhood Education Kathryn Ohle stated,

Going to Chevak to teach Family Community Partnerships was life changing. It forced me to really think about the contexts in which we work while also recognizing and embracing the values of the community of Chevak and not those necessarily characteristic of the university community. We talk about culturally responsive pedagogies but I did not fully understand what that looked like until I was there, interacting with these paraprofessionals who will change what education looks like for the next generation. I am a better teacher and a better citizen because of my experience there. (Kathryn Ohle, university faculty, August 10, 2014)

With four students already receiving their associate's degrees and many others closely following suit, this is an initiative that has provided and will continue to provide support to the community by helping them "grow their own."

STEAM Curriculum

The STEAM Curriculum project began in 2013 when a UAA faculty member, Dr. Irasema Ortega, began discussions with community members, in particular inservice teachers, about the science curriculum within the Immersion Wing. Dr. Ortega saw the possibilities of connecting the existing curricula to the preservice teacher initiative through collaborative efforts to create curricula via methodology and other courses. Before that, the science curriculum implemented in the K–4 immersion school was not available in the form of written lessons. At best, it was written in an abridged format. Previous efforts had involved a project in which twelve paraprofessionals worked alongside inservice teachers to produce picture books about the animals and plants found in the village and the surrounding tundra. (See Figure 2.) This project extended the effort by integrating the books as well as oral stories, plays, photography, and other forms of artistic expression into the immersion curriculum.

In our cooperative effort, our team shared a common goal: to design a curriculum map and lessons that address the revitalization of the language, culture, and traditional ways of knowing in science in an integrative fashion. (See Figure 2.) We also sought to address two needs: (1) the need to cooperate with the educators and community members in the village, and; (2) the framing of a curricular approach that addresses the preservation of their language, culture, and ways of knowing in science. Thus, we adopted the model of Culturally Sustaining Schooling (CSS). Given the wealth of Indigenous knowledge and its role in preserving the cultural and linguistic traditions, this approach validated Cup'ik traditional knowledge of nature and technology and allowed for three intertwined elements: culture and tradition, personal stories, and the stories uncovered in knowledge construction and use.

During the initial phase of the curriculum project, we worked with K–3 teachers at Chevak School and a cultural advisor to create integrated STEAM curriculum that was culturally responsive. The curriculum units were developed in Cup'ik and English and included both Western and Cup'ik perspectives. The stakeholders spent the first three days in the teachers' lounge listening to stories about traditions and local knowledge. For example,

Making a kayak takes a lot of time and skill. When I was a young man, I started making my own kayak. First, I had to measure four arm lengths to figure out how long the kayak had to be. I had to build it according to my height and weight and it could only be off by ten pounds; otherwise, it would sink in the cold water. I would go out and collect pieces of birch wood. That took a long time. We do not build kayaks like this one anymore. The other day I set the traditional tools for kayak-making right here, by my kayak, next to the modern tools. Then I brought my father and asked him which set of tools he would choose to build a kayak. He looked at me and replied: I would use the Western tools; that way it would take less time and I can have more time for seal hunting and fishing tools. (James Ayuluk, summer of 2012)

In this story, the narrator clearly illustrated the idea of the two rivers of knowledge and the desire to engage Alaska Native students in traditional knowledge using modern materials and technology. It was also clear that traditional knowledge included well-defined elements of science, technology, engineering, arts, and mathematics. These are some of the elements that helped define the curriculum project and illustrate why it is important that the local ways of knowing be documented and shared. The curriculum that is documented is subsequently integrated into coursework for the preservice teacher cohort as well as for science methods courses at UAA.

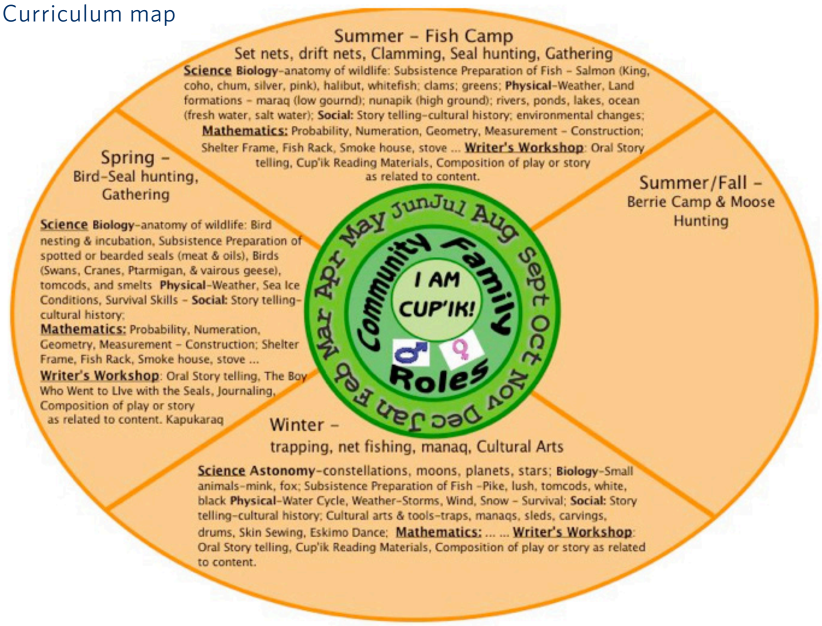
Below is the curriculum map that was generated during this project.

Local Atlas of Plants and Animals

The atlas project was another initiative that focused on the revitalization of language, culture, and place through Indigenous ways of knowing in science. An example of the synergy and connections this initiative has fostered started in 2013 and ended in 2014. During this project, an elementary preservice teacher and Irasema Ortega, who is a science education faculty member, collaborated with Alaska Native Elders, parents, teachers, and students to design and prepare an atlas of plants and animals based on traditional knowledge of subsistence practices, which the community members would then own and disseminate as they wished. During this project, members of the community provided valuable information and guidance used in the preparation of the atlas. Pictures were collected from a local photographer and cultural consultant and from the State of Alaska Fish and Wildlife website. It culminated in a tablet-based atlas for the community members to use as they wished.

This project also resulted in a meaningful experience for both the preservice teacher and UAA faculty member, as it reinforced the importance of learning from the community and understanding the characteristics of shared cognition of ancestral Indigenous knowledge of place, culture, and language. Thus, the atlas of plants and animals exemplified a mutually beneficial civic engagement project and also demonstrated an alternative approach to engagement with an Indigenous community. Further, it is representative of the connections the partnership has fostered toward the common goal of linguistic and cultural revitalization.

FIGURE 2.
Curriculum map



Language Revitalization Through Children's Books

This is a project that reflects the wisdom of Elder Cecilia Pingayak-Andrews. When one of the UAA faculty visited with her during the Atlas project, she was asked: what would it take to retain the language and culture? Her answer was clear and definitive. " Children learn our language on their mother's lap. But how are we going to keep the language alive if the parents themselves do not speak it?" (Cecilia Andrews, informal interview, July 2014).

With that wisdom in mind, a project was initiated with Unite for Literacy, an organization working towards creating an abundance of books through a free, digital library with books that celebrate the languages and cultures of all children while also cultivating a lifelong love of reading. This project hinged on the amazing talents of the paraprofessionals from Chevak School (another indication of the ways in which the various facets of this collaboration work together), who helped translate the books into Cup'ik and narrated them. There are now thirteen books that can be heard in Cup'ik, and by the end of the project in 2015, an additional thirty-seven books will be added. Plans are also in the making to "localize" the books by using pictures from the Alaska context and then to print them as hardcopy books, which will be shared through interested Head Start organizations. This will not only make them available to families without access to the Internet but will also show the community that both their language and culture are recognized in print. Positive support from the On-site Coordinator of the Chevak Head Start has already been expressed, who commented,

> *We are very excited for our Head Start program to be considered to receive our Cup'ik culture's tools such as the books you are offering. They are going to be used by our entire staff, Elder Mentors, and volunteers. And it is a bonus that the local Chevak School's paraprofessionals are the ones who help create them. It will help our entire staff to work together to add 1 to 2 of these books per week into our lesson plans, so our students will hear and see our Cup'igtaq language.* (e-mail correspondence, February 25, 2015)

While this project is still in process, the hope is that by providing materials in the native language, both early literacy and language preservation will occur "on the mother's lap."

Language Revitalization through Writers Workshop

The final project that is currently underway seeks to promote language revitalization while also documenting the preservation of language and ancestral knowledge of how to coexist in harmony with the environment. This will be done through a writers group, where manuscripts will be developed and featured as participant-authored chapters in a book for Emerald Publications (working title, Language Revitalization and Culturally Sustaining Pedagogies in Teacher Education Programs), which is due to the publisher in January 2016. This project was initiated as a result of a UAA faculty member's experiences with the cohort as an instructor in a class in which participants shared stories from their lives. It is a project that connects the preservice teachers with their cultural identities through stories, while also providing experiences in methodologies that can be used in classroom teaching. In addition, research focusing on the viability of writers groups as tools for sustaining linguistic and cultural identity will be conducted.

The stories of the participants are powerful, because although contact is for the most part detrimental to their identity as Alaska Natives, they have persisted in their goals. Their stories are examples of self-determination and agency, and they inform our present and future work. They are collective, they can be healing, and they will become powerful publications in every genre.

Discussion

These projects, including a teacher education plan, a collaborative STEAM curriculum project, the creation of a local atlas of plants and animals important to subsistence, and a language revitalization initiative using a children's book project and writing workshop, were initiated to address the needs of K–20 students and their teachers, while preserving the Alaska Native cultures, languages, and subsistence ways of life. As we continue to work collaboratively toward sustaining place, language, and culture, we find that the future of our partnership, and of future partnerships, resides in relationships, mutuality, and creativity. Together, we pursue projects that are transformative and sustaining. Such projects have no pre-existing frameworks. They are based on our strengths and on our relationships, and those will last a lifetime. The biggest threat to this and future partnerships is a lack of funding, but we remain hopeful (and we continue to seek funding).

While results of our ongoing efforts are forthcoming, our hope is that this synergistic approach might act as a framework for others working towards similar goals.

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PROJECT REPORT

Weird Science: Ten Years of Informal Science Workshops

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Introduction

As educators, we are frequently challenged to develop interesting and educationally robust methods for the promotion of critical thinking in our classrooms. Once our students have graduated, the opportunities for them to further develop their critical thinking skills are greatly diminished. For the last ten years I have conducted informal science outreach workshops outside of the classroom setting, which I call "Weird Science." In the discussion that follows, I'll introduce the concepts behind these workshops and the strategies I have used to promote science and critical thinking skills among diverse audiences. I'll conclude with some challenges I have encountered and provide anecdotal feedback from attendees on the significance of these events.

Weird Science

Weird Science workshops are part journal club, part citizen science project, and part stand-up comedy. Having previously written for the Annals of Improbable Research, I have adopted their slogan of making "people laugh and then think." Through Weird Science I have appeared before diverse audiences including lunch clubs, summer school programs, book clubs, science fiction conventions, and MENSA chapters in informal learning environments such as public libraries, hotel ballrooms, gymnasiums, waterparks, bars, restaurants, and churches. Each session typically lasts from sixty to ninety minutes and includes a review of three to four science articles and participation in a hands-on experiment. Both parts are designed to be interactive and foster maximum audience participation in the form of a group discussion on data review/analysis and a hands-on activity. The content is tailored for either adult or family audiences.

The educational framework of Weird Science is based on training I received in the philosophical, pedagogical, and scientific aspects of education through the Fellowships in Research and Science Teaching (FIRST) program, which is cooperatively organized through Emory University, Clark Atlanta University, Spelman College, and Morehouse College and School of Medicine. This fantastic program combines a traditional post-doctoral research experience with formal instruction on teaching and learning methods, with a mentored teaching experience at one of the minority serving institutions in the Atlanta area. Specifically, I have covered topics drawn from Barbara Davis's book Tools for Teaching, which was used as a text for this program: encouraging student participation in discussions, tactics for effective questioning, fielding student questions, and alternatives to lecturing. Although the book focuses on formal classroom techniques, I have found many of its principles to be applicable to informal teaching as well.

Weird Science contains many of the strands recently outlined by the National Research Council for learning in informal spaces. These include reflecting on science as a process, participating in science activities involving scientific language and tools, manipulating, testing, and exploring the natural and physical world, and experiencing excitement and motivation to learn about our world (Bell et al. 2009). My goal is to make each one a funny, educational, and informative session for everyone, regardless of their age or science background.

FIGURE 1. The author presenting a Weird Science workshop in late 2014. The caption on the image behind the author reads "Because Chocolate Can't Get You Pregnant."

Part Journal Club

The majority of a Weird Science workshop is composed of audience analysis and discussion of scientific articles as typically found in a science journal club. The types of articles I draw from include primary, peer-reviewed literature as well as reports from the mass media. In many cases, this is the first time audience members have ever been exposed to a peer-reviewed publication, and I find demystifying the scientific literature to be an important goal. While the prospect of fostering a discussion of primary scientific articles involving individuals with diverse science backgrounds may seem daunting, the selection of appropriate papers has been the key to success. I have found that the most appropriate types of publications typically include topics with a minimum of background information needed to understand the hypothesis, experimental methodologies with simple designs used to address that question, and most importantly a subject which can quickly grab attention and stoke curiosity. For example, little background knowledge is needed to understand the importance of identifying methods to safely transplant animals to new habitats, such as those discussed in "Transplanting Beavers by Airplane and Parachute" (Heter 1950). Participants can easily understand the experimental design in "Testing the Danish Legend That Alcohol Can Be Absorbed through Feet: Open Labelled Study" (Hansen 2010), where subjects immersed their feet in vodka for three hours and then monitored their blood alcohol levels. Finally, the papers already mentioned and many others, including "My Baby Doesn't Smell as Bad as Yours: The Plasticity of Disgust" (Case et al. 2006), "Robot Vacuum Cleaner Personality and Behavior" (Hendriks et al. 2011), and "Do Women Spend More Time in the Bathroom Than Men?" (Baille et al. 2009) illustrate how a great subject can quickly pique interest.

By using these examples, and many others over the last ten years, I have been able to guide participants with little to no formal training in science through a critical review of the scientific methodology, data analysis, and conclusions presented in these publications. For example, when asked to design their own mezthod to test the myth of alcohol absorption through feet, many audiences initiated spirited discussions concerning what type of alcohol to use (percentage alcohol content) and what controls would be appropriate for such a study. Participants then contrasted their experimental designs to the one used in the published report, which opted for vodka (37.5 percent alcohol by volume) but included no real controls (Hansen 2010). For the study "Robot Vacuum Cleaner Personality and Behavior" (Hendriks et al. 2011), which surveyed a population of six individuals as part of their methodology, participants correctly recognize that such a small sample size does not provide statistically reliable support for the conclusions drawn by the authors. The differences between hypothesis-driven research and observational types of science can be illustrated through case studies such as "Pharyngeal Irritation after Eating Cooked Tarantula"

(Traub et al. 2001). Mass media articles like "Swedish Cows Make Lousy Earthquake Detectors" (The Local 2009) can be used to explain what peer review is and to promote a discussion on the differences between peer-reviewed scientific literature and reports from mass media sources. The history of science can be explored through publications such as "The Behavior of Young Children under Conditions Simulating Entrapment in Refrigerators" (Bain et al. 1958). In the end, science articles like these are ideal for stimulating discussions about the scientific method and data analysis in individuals, regardless of their formal scientific training.

While finding appropriate journal articles with these characteristics within the vast body of published literature may seem overwhelming, there are actually many resources that one can mine. Both the Annals of Improbable Research and the Journal of Irreproducible Results feature odd science topics in every issue. There are also a wealth of blogs including Sci-Curious (https://www.sciencenews.org/blog/scicurious) and Seriously, Science? at Discover Magazine (http://blogs.discovermagazine.com/seriouslyscience/), which highlight strange science publications. Additionally, many end-of-year "best of" lists now include odd science discoveries in their categories. Fortunately, I have always had some form of academic position that has included access to nearly all of these publications through the fantastic library resources found at colleges and universities across the United States. With the gradual adoption of open access policies, many of these articles are now accessible for free to participants after the workshop.

Part Citizen Science Project

The last third of a Weird Science session involves audience participation in examining a scientific question. It has been suggested that involving the public in citizen science projects can impact their understanding of science content and the process of science (Cohn 2008). While most citizen science projects are long-term studies in which participants play a minor role, these exercises are smaller in scale and are selected so that participants can be actively involved in both data collection and interpretation. I again draw directly from the primary literature for inspiration; previous topics have included stall preference in public bathrooms (Christenfeld 1995), left/right-side preference for tasks such as holding a small dog (Abel 2010), and whether Dippin' Dots (tiny frozen spheres of ice cream) can cause ice cream headache (Kaczorowski and Kaczorowski 2002).

While the exact series of steps differs depending on the topic of investigation, this section typically includes a brief discussion on the background knowledge behind a specific scientific question and an experiment in the form of a hands-on activity or survey to test the discussed hypothesis. For example, Chittaranjan and Srihari published a report in the Journal of Clinical Psychiatry examining nose- picking behavior in two hundred school-age children in Bangalore City (Chittaranjan and Srihari 2001). As the instrument used in that study is included in the article, I would hand out that short survey and ask that any interested individual anonymously answer the questions on their nose-picking behavior. Once these responses are collected, I would introduce the publication and discuss any limitations in their methodology, in this case issues such as reporting honesty by respondents and response selection bias when using surveys. The group then discusses the results from the paper allowing attendees to compare their own personal answers to questions like "Do you believe that nose picking is a bad habit?" and "Do you occasionally eat the nasal matter that you have picked?" to the complete data set from the article (Chittaranjan and Srihari 2001).

While I vary the articles I cover for every Weird Science workshop, I conduct the same scientific experiment for all presentations during a calendar year running from July to June. This allows me to amass a large data set examining a specific hypothesis and to correlate results from the Weird Science experiments with results from the original manuscript. Most venues invite me back annually, which means I can present the cumulative data set from the complete year upon my return visit and allow the audience to draw parallels and conclusions from our data in relation to the original published study. Most importantly, we discuss how no scientific study is perfect and identify the limitations of our own study methods, which impact how we can analyze the data and draw conclusions from it.

Part Stand-Up Comedy

In the last few years, publications have appeared examining the use of humor in science communication with both positive (Roth et al. 2010; Pinto et al. 2013) and negative conclusions (Lei et al. 2010). While acknowledging that there can be positive effects of humor in education, Lei et al. also comment that some types of humor can be viewed as offensive and therefore unfit for a classroom setting. Additionally, humor that is excessive or forced may also be viewed as negative and can undermine the credibility of the educators (Lei et al. 2010). Through an analysis of video tape recordings of first-year teachers, Roth et al. describe multiple types of humor in the classroom and identify laughter as "a collective interactive achievement of the classroom participants that offsets the seriousness of science as a discipline" (Roth et al. 2011).

I rely heavily on humor as an instructional and entertainment tool that takes three general forms. First, many of the articles themselves contain classic bits of humor I can draw from directly. For example, in the study "Observing a Fictitious Stressful Event: Haematological Changes, Including Circulating Leukocyte Activation," the authors determine whether immune cells are activated when participants view a fictitious stressful event by having them watch "The Texas Chainsaw Massacre" (Mian et al. 2003). In commenting on the study's conclusions disproving the Danish myth of absorbing alcohol through the feet, the authors write, "Driving or leading a vessel with boots full of vodka seems to be safe" (Hansen et al. 2010). Secondly, as I typically use PowerPoint as a method of delivering figures and images from these publications, I can draw on the extensive collection of clip art from the internet to graphically enhance my presentations. Finally, the responses from participants themselves during the experimental portion are often excellent sources of humor. When reviewing the results of our test to see whether a modelling clay activity can alleviate chocolate cravings, I show pictures of some of the clay creations made during that activity. While I encourage everyone to treat the experiments with an appropriately "serious" attitude, I see a wide range of interpretations. In response to a question concerning their favorite ice cream flavor, participant answers included "blue," "orange sherbet," and "Ben and Jerry's Vanilla Nut Cream of the shimmering hills crowded among the snowy valley." As part of a study on body hair patterns, participants responded to a question on unusual body hair locations with answers including "I have it on the tops of my feet but no, I am not Frodo Baggins" and "Only when I am around my cat." While not necessarily fulfilling the intent of the questions asked, these responses are funny in a good-natured way and provide a great teachable moment to illustrate some of the challenges of using surveys as a research instrument.

FIGURE 2. Clay creations made by attendees in 2013, testing whether working with modeling clay can alleviate chocolate cravings.

It has been suggested that humor may not be an appropriate tool for science communication as audiences lack the background knowledge to get the jokes (Marsh 2013), speakers present themselves as elite individuals (science experts) elevated above the audience (Marsh 2013), or because humor can only be derived when the audience asserts their superiority over the shortcomings of the particular situation (Billig 2005). I would instead argue that humor is a powerful tool in any educational setting, and that these pitfalls are avoided by the organization and delivery of Weird Science. The audience members themselves serve as the scientists as they work through the various analysis and experimentation exercises. Consequently I serve more as a "guide on the side" rather than as an all-knowing "sage on the stage." My selection of articles specifically ensures that extensive background information is not needed to get any particular joke and shows that critical review is an integral part of the scientific process, which need not include an air of superiority. Finally, humor is essential to making these sessions entertaining and promoting a general feeling that an audience's time has been well spent.

Putting It All Together

To demonstrate how all of these parts come together to form a complete program, I'll describe a recent workshop I presented at the Multiple Alternative Realities Convention (MarCon) in Columbus, Ohio. The workshop lasted approximately seventy-five minutes and began with a discussion of "Do Bees Like Van Gogh's Sunflowers?" (Chittka and Walker 2006). I used this paper to foster a discussion on the study's methods, which measured the preference of bees to pictures with and without flowers, using different media for each image; these included posters with reprints of original works, oil on canvas, and an acrylic on canvas board reproduction of Van Gogh's painting by another artist. Audiences noted that the inconsistent use of media complicated the interpretation of bees' preferences for the images. Next we reviewed the results from the previous year's citizen science project "The Use of a Modeling Clay Task to Reduce Chocolate Craving" (Andrade et al. 2012). After reviewing the results from the study, the audience contrasted the published methods with the study they participated in and noted that while the original had selected for individuals who self-described as "chocolate lovers," our population was not pre-screened in such a way. This may have contributed to our failure to reproduce the study's findings.

Next the paper "Skipping and Hopping of Undergraduates: Recollections of When and Why" (Burton et al. 1999) was presented. The authors of the paper highlight that one percent of undergraduates surveyed report never having skipped or hopped, which the audience noted may reflect more on the selective memories of the respondents and the limitations of surveys as experimental instruments than on actual events. The case report "The Case of the Haunted Scrotum" (Harding 1996) was used to illustrate the difference between hypothesis-based research and observational science. Finally, the audience was challenged to design an experiment to test whether watching different types of television programs would impact the amount of food being consumed during snacking, as studied in the paper "Watch What You Eat: Action-related Television Content Increases Food Intake" (Tal et al. 2014). We closed the workshop with a new citizen science project examining the types of rubber glove creations attendees would make in the setting of a pediatric doctor's office to calm an upset child. Once I recorded the types of creations made, the audience then compared their creations to child preferences in the study "The 'Jedward' versus the 'Mohawk': A Prospective Study on a Paediatric Distraction Technique" (Fogarty et al. 2014).

Challenges

While I have loved presenting these workshops, they have not been without their challenges. Because of the diversity of scientific backgrounds in audience members, I have seen participants with more science experience unintentionally dominate discussions. The job of moderator is an important one and requires a sensitive touch in these informal settings to maintain a balance between a lively group discussion and basic crowd control. Additionally, while I have often found myself presenting in bars, I have luckily never found the inclusion of alcohol to be a negative factor. However, its presence can change the discussion dynamics, and I am always on guard in such situations for alcohol-related complications such as heckling.

I find identifying appropriate articles to be relatively easy, but designing the hands-on component has proven to be more complicated. The diversity of locations where I present limits the types of hands-on experiments that can practically be done. Surveys have become an easy solution to these logistical issues, but I have tried to use them only sparingly, when I can't identify another subject that involves more active experimentation. As a majority these workshop are free, the cost of any reagents (ice cream, chocolate, rubber gloves, etc.) comes directly out of my own pocket, and a lack of external funding further limits experimental complexity.

Occasionally, I have perceived a slight air of disappointment from participants when our attempts to replicate a published scientific study fail, as in the clay modeling activity to alleviate chocolate cravings. While situations such as this provide excellent educational opportunities to discuss how the process of science is full of errors and failed experiments (for whatever reason), a lack of exciting results does work against the entertainment goal of the workshops. I have tried to redirect negative feelings through analogies to the TV show *Mythbusters* by discussing how replication is the foundation of science and how our negative results may have disproved a questionable hypothesis (with caveats regarding differences between our experimental method and the published study).

Anecdotal Feedback

I have honestly been thrilled with the level of success I have experienced with Weird Science. I have never made a formal attempt to evaluate the effectiveness of these sessions or track my attendance numbers, but written responses to the experimentation portion over the last four years can be used to at least measure the number of attendees participating annually. For each year from 2011 through 2014, between

192 and 207 people participated, with ages ranging from 17 to 79 years. This included approximately equal numbers of male and female respondents. I would estimate that at any one workshop, between one half to two thirds of attendees participate in the science experiment.

Finally, the success of these sessions has led me to create a Facebook group called "Weird Science with Rob Pyatt" to continue similar scientific discussions outside of the workshops by using social media. In preparation for this paper, I asked group members who had previously attended a workshop a few questions regarding their views on and experiences with Weird Science sessions. While this is far from a scientific evaluation, I think these anecdotal responses begin to illustrate the value in this unique informal education format. When asked if something surprised them about a Weird Science workshop, two individuals responded "The amount of time devoted to discussing data collection and study. I learned more about how science works than any actual science itself," and "Science can be fun." When asked why they took the time to attend a Weird Science workshop, answers included "Because you don't just lecture, you involve everyone in the process so that they understand how a scientific study should work," and "Learning and entertainment!" One final comment from a participant concerning why they have attended a session in the past, "You engagingly discuss science in a way that I who has a minimal science background and my fiancé who has a degree in chemistry can both enjoy." I'll close with an unsolicited comment I received in 2013 from a mother who had attended a session with her daughter; I hope it serves to illustrate the impact these workshops can have. She posted "Just wanted to let you know that you are an influence on young minds. My mom was talking about some 'study' she saw on TV (with a test group of one) and my daughter immediately started countering with all the reasons this was NOT a scientifically valid study. So proud!"

About the Author

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PROJECT REPORT

Connecting to Agriculture in Science Centers to Address Challenges of Feeding a Growing Population

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Abstract

The need to feed nine billion people by 2050 looms large. While the problem is complex, increasing civic engagement around the need and the potential solutions must be emphasized. Museums are fundamental places for the public to support efforts in public education to re-emphasize the connections between agriculture and science, technology, engineering, and math (STEM) fields. Yet many science museums do not explicitly highlight those connections through exhibits. The authors categorized a sample of science museums across the country into small, medium, and large, based on square footage, annual attendance, and operating expenses, and took inventory of exhibits at each museum. As we suspected, we found a general lack of exhibits explicitly labeled as agricultural but a high percentage of exhibits related to agriculture content or practices. Thus, we suggest science centers could re-brand existing content and programs to address civic engagement around agriculture to feed our growing population.

Introduction

Estimates suggest that by the year 2050, the world will have a population of at least nine billion people, nearly two billion more than today (Godfray et al. 2010; Leaders of Academies of Sciences 2012). Furthermore, we know that the world faces challenges of adequately feeding even the current population, in both wealthy and developing countries. How will we meet the challenges of producing and distributing enough food for even more global inhabitants, especially while preserving the natural resources needed to continue to do so long term? This is the crux of the food security challenge facing the world, a challenge that crosses applied fields like agriculture as well as the underlying basic disciplines of science, technology, engineering, and math (STEM).

Much of the public support for research funding and decision-making around food issues will rely on an understanding of the connections among such basic research and agricultural fields. Museums are beginning to realize their role in assisting in such civic engagement, though they have yet to take full advantage of their existing resources to do so (Kadlec 2009). Many across the spectrum of content types (e.g., science, art, or history) are already exploring exhibits and programs related to food (Merritt 2012). However, other museums may not feel that food is in their mission, or may not know easy ways to contribute to conversations about food and agriculture or connect existing resources without large inputs of time and effort (Merritt 2012). Further, they themselves may not connect the applied discipline of food production with basic science and research, or even with their current efforts at sustainability.

Science museums, more often called *science centers* in their professional associations, are natural contexts for agriculture and food security issues, given their existing focus in both exhibits and programming on the basic disciplines. Such support could simultaneously encourage public involvement and action on the issue and inspire and prepare the necessary future Ag-STEM research workforce. Indeed, at least a few science centers already offer agricultural connections ("Tapping into Agriculture" 2014). This article investigates the broader potential for integrating agriculture into science centers. Specifically, it examines the existence of agriculture-related content, including that related particularly to food and food security, in science centers across the United States.

Review of Literature

From the 1950s-1980s in the United States, agricultural education in secondary school was essentially separated from science and math (S1057 Multistate Research Project 2012), and to some extent from technology and engineering. Agricultural education was considered a pathway to a career immediately after high school graduation, part of a vocational program (National Commission on Excellence in Education 1983; Phipps et al. 2008), while STEM classes, especially at the advanced level, were considered preparatory classes for college (Oakes 1986). This separation persists (Oakes and Saunders 2008) and may be one reason for the lack of STEM contextualization for learning through secondary school and the dropout of students from STEM career paths. Therefore, this persistent separate tracking could be a factor in the scarcity of STEM-skilled, and particularly Ag-STEM-skilled, workers in the U.S. workforce.

Calls to re-emphasize the STEM fundamentals inherent in agricultural programs (Enderlin and Osborne 1992; Hillison 1996; National Research Council 2009; Thoron and Myers 2008) aim to address the need for STEM-skilled workers, particularly in the agricultural industries and agricultural research. Existing problems of food insecurity, sustainability, and looming global crises of feeding a growing population demand interdisciplinary research and solutions (Godfray et al. 2010; Schmidhuber and Tubiello 2007; Guillou and Matheron 2014).

Another fundamental problem thought to plague STEM education is a lack of real-world context (National Research Council [U.S.] 1996; Rivet and Krajcik 2008). STEM fields struggle to retain students and excite them about careers, suffering especially from a lack of real-world connection and, especially for women, connection to helping people (White 2005; Wilson and Kittleson 2013; Herrera et al. 2011; Maltese 2008; Carlone and Johnson 2007).

However, school is neither the only place, nor necessarily the most frequent place, a person learns. In a typical American's lifetime, over 95 percent of one's time is spent outside of a formal school context, and even during formal school years, a significant portion of one's time is spent away from the classroom (Falk and Dierking 2010). That time may be spent on paid or volunteer work, recreation, socializing, or family, among other things, meaning that there is a significant influence of these social and community groups on learning (Rogoff 2003; Vygotsky 1978). The preponderance of out-of-school influence means that to truly re-emphasize the interconnectedness of agriculture and STEM, learners must see the connections throughout their lives, not only in their formal classrooms.

The adult public in the United States has long been thought to be able to benefit from increased science knowledge and skills, which could result in more able and engaged participation in the workforce (Carnevale et al. 2011) and in our democracy (Meinwald and Hildebrand 2010; Miller 2010). The majority of workforce indicators predict a further skills gap in the coming years between employers' needs and employees' skills at the time of hire (Carnevale et al. 2011; Goecker et al. 2010; Committee on Prospering in the Global Economy of the 21st Century [U.S.] 2007). Further, as recently as 2008, roughly 70 percent of U.S. adults were thought to be unable to read and make use of *The New York Times* Science section (Miller 2010), one metric lately used to track the effectiveness of science communication for broad outreach and baseline science "literacy." However, many adults, once finished with their degrees, do not return to formal school for additional learning.

Science centers play a major role in adult and out-of-school science learning (Falk and Dierking 2000). In fact, they naturally embrace many of the ideals inherent in the Next Generation Science Standards (NGSS) for secondary school science learning: question-driven, learner-centered, hands-on, and integrated development of knowledge, practices, and abilities (Bell et al. 2009). They also attract a wide audience of learners each year, both school groups and independent visitors (Falk and Dierking 2000). These days, less than 2 percent of the U.S. population lives on a farm (National Institute of Food and Agriculture 2015), and informal education institutions are one major potential source of adult learning about agriscience.

While students are in formal school, agriscience teachers may use science centers to reinforce agriscience learning, and these field trips may be especially important for rural residents. In the United States, agriculture is often overlooked as an explicit component of formal curricula in science, technology, engineering, and mathematics, whether those curricula are integrated as STEM or separate, and agriculture may also be disconnected from these domains in the minds of the public. Reconnecting agriculture with its research and engineering underpinnings in public spaces through the context of food can reinforce the interconnectedness between them that some students learn in school, or provide connections for students who still experience the Ag-STEM subjects independently of each other.

Without connections to agriculture in these everyday settings, the artificial intellectual divide between agriculture and other science domains in the minds of the public may be perpetuated. This public divide can hurt not only efforts to prepare school children to be future Ag-STEM researchers and workers but also efforts to involve the public in decision-making for sustainable food production for our future population.

Science centers have begun to explore ways to be more involved in public scientific issues (Kadlec 2009; McCallie 2010; Worts 2011). Moving beyond simply presenting engaging information and experiments on accepted science, many are beginning to introduce exhibits and theaters that explore science at the forefront, aiming to present science and technology as it emerges, with all the surrounding ethical, economic, and environmental considerations. The Café Scientifique, or Science Café, movement is explicitly trying to foster public dialogue about these considerations and issues by bringing the public together in forums designed to encourage discussion with experts (Dallas 2006; McCallie 2010).

Previous special journal issues, including *Museums and Social Issues* in April 2012 and the March/April 2014 volume of the Association of Science-Technology Centers' *Dimensions,* explored case studies of exhibitions related to food in more detail, including internationally. However, little attention has been paid so far to a broader, field-wide emphasis on bringing agriculture to all science center visitors and thus to a significant portion of the U.S. public. The focus on food also could neglect the broader story of agriculture and its global effects from start to finish, from research to production to distribution, with its STEM basis as well as its context that touches everyone.

Purpose of the Study

For the many reasons outlined, science centers are ideal places to start to support efforts to make explicit and emphasize the Ag-STEM connections for all of their audiences. Indeed, we suspect that in many cases existing exhibits and programs could support Ag-STEM efforts without major renovations; in fact, such emphasis may require only minor adjustments to language and framing in promotional and educational materials, programs, and the exhibits themselves. Therefore, this study sampled large and small U.S. science centers to determine which and to what extent existing exhibits have explicit or underlying relations to agriculture that could be exploited for Ag-STEM integration emphasis purposes.

Method

A sample of science centers in the United States was created, spanning geographical and size diversity to the best extent possible. A list of the top ten science centers by 2010 annual attendance (Walheimer 2012) was the starting point for devising the sample of large science centers. To this list were added well-known large museums or centers that were not on the list due to lack of membership in professional organizations, namely the Smithsonian Air and Space, American History, and Natural History Museums, The Perot Museum of Nature and Science in Dallas, Texas, and the Houston Museum of Natural Science. The addition of these centers to our list increased our geographic diversity by including Texas and Washington, D.C. (A complete list of science centers and locations is provided in the Appendix.) Estimated annual attendance, total exhibit square footage, and annual operating budget were confirmed via center web sites, annual reports, or phone calls to ensure they all had similar resources. The minimum criteria for inclusion in the list was a budget of 10 million dollars annually and visitation of at least 200,000. Centers were neither excluded nor included based on square footage, as reliable estimates of exhibit space versus total building space could not be obtained for all centers.

For the sample of small- and medium-sized science centers, an online alphabetical list of member science centers from the Association of Science-Technology Centers ("List of Science Centers in the United States" 2013) was numbered. A list of random numbers was generated at http://www.random.org and then each center that matched the first fifteen numbers in the list of random numbers was chosen. Centers were confirmed to be still in operation, not on the list of large centers already generated, and not in the same city as the large centers. If a center was excluded in this process, the next random number on the list was matched and confirmation continued in this manner until there was a total of 15 small- and medium-sized centers.

Next, in January 2014, the web sites of all the identified centers were visited and the page that listed all of their exhibits found. Counting everything the science center itself listed as an exhibit on those pages, the exhibit titles and brief one- to three-sentence description of each exhibit listed on that page were recorded. For example, the Museum of Science, Boston, lists their exhibits at http://www.mos.org/exhibits; on this page, each exhibit is listed with a title, such as "A Bird's World," followed by a short description, "Take a virtual tour of Acadia National Park in this exhibit, which includes a specimen of every bird found in New England." The link following that description takes the viewer to a longer description, and the first paragraph on each of those individual exhibit pages was captured for the long description. Therefore, there were up to three pieces of data for each exhibit at each center: exhibit title, short exhibit description, and long exhibit description.

TABLE 1. Topics related to agriculture based on the AFNR Career Clusters

AFNR Career Cluster[a]	Example Related Topics[b]
Animal Systems	Animals, people, nutrition
Biotechnology Systems	Biology, microbiology, biochemistry, molecular biology
Environmental Service Systems	Climate Change, waste management, chemical systems
Food Products and Processing Systems	Food and food production
Natural Resource Systems	Water, soil, land, air, energy
Plant Systems	Plants and their life cycles
Power, Structural, and Technical Systems	Energy, technology, engineering, mechanics

[a]There is an eighth career cluster in the standards, Agribusiness Systems. However, since it did not include any new agriculture content, but encompassed all the other content in the context of business, we did not add any related topics based on this cluster.

[b]Math is part of all of the standards, and is therefore another topic we counted as "agriculture-related."

To determine which exhibits were related to agriculture, the titles and the short and long descriptions that explicitly used the term agriculture were noted first. Next the titles and descriptions of topics were read again to identify those that were related to agriculture, based on seven of the eight pathways of the National Agriculture, Food, and Natural Resources (AFNR) Career Cluster Content Standards (National Council for Agricultural Education 2009).

Each title and short and long exhibit description was qualitatively coded (Auerbach and Silverstein 2003; Patton 2002) as to whether or not it was related to agriculture. In other words, was the title or short or long description related to one or more of the eight pathways of the AFNR Career Clusters? We coded each as clearly related; probably related but somewhat unclear from the limited information given; probably not related but an argument could be made for its relatedness; or definitely not related. Some exhibits did not have content that was related to Ag-STEM but were definitely designed around Ag-STEM skills, such as observation, finding patterns, or modeling; these exhibits were coded specifically as skills and included in the counts of related exhibits. The author and a research assistant worked together to develop the codes and coded one large science center's exhibits together. After they had agreed on the meaning of the codes, each coded half of the large and small science centers.

Special Note: The National Ag Science Center

Despite its name, the National Ag Science Center in Modesto, California, does not yet have a physical space, and therefore, was not part of our study. However, since they are already fluidly combining the traditional material of science centers with the agricultural context required to address problems of feeding more and more people, they serve as an example here. As Center Director Michelle Laverty notes, "Few [students] make the link between math and recipes, density and soils, or light and plant growth. Students also have a limited view of careers in agriculture" (Laverty 2014, 28). The National Ag Science Center also exemplifies the ideal that it doesn't take a large-city science center to bring meaningful content to students. The students they serve in their county live at least two hours from San Francisco.

The Ag Science Center's two main programs are examples of the ways existing science content can be contextualized with agriculture through hands-on exploration and through local partnerships. First, lab experiences in the mobile lab of the Ag Science Center connect typical experiments—such as testing pH or using a microscope—to agriculture and food production by testing soil pH or examining beneficial insects for crops under the microscope. Second, their summer camp paired local FFA students working in agriculture with middle-school campers using similar hands-on contextualized experiments and allowing the two groups of students to share with each other (Laverty 2014).

TABLE 2. Large Science Centers Exhibit Coding

	Titles	Short Descriptions[1]	Long Descriptions[1]
Clearly related	106	86	110
Probably related	20	6	8
Probably not related	30	3	9
Definitely not related	143	154	159
Skill	17	12	19
Biography	0	1	1
Total exhibits	316	262	306
Percentage agriculture related[2]	45	40	45

[1]Not all exhibits had both a short and long description.

[2]*Agriculture-related* is the total of clearly related, probably related, and skill exhibits.

Results

Overall, of the large centers sampled, none had *agriculture* in the title or short exhibit description, and only four of 316 exhibits sampled explicitly had agriculture in the longer exhibit descriptions. However, fully 45 percent of the exhibits were at least probably agriculture-related based on the titles and long descriptions, 40 percent when considering the short descriptions. (See Table 2.)

Take, for example, the St. Louis Science Center, one of the large science centers examined. A list of some of the exhibits and their long descriptions appears in Table 3. The website did not list short descriptions at the time of analysis. None of the exhibit titles and only one description, for the Life Science Lab, explicitly uses the word *agriculture*. Yet only four of the 18 exhibits—the Energizer Machine kinetic sculpture, Planetarium, Experience Flight simulator, and Amazing Science Demonstrations—are not obviously related to agriculture in the AFNR Career Clusters, based on the titles and descriptions provided. The Planetarium and Amazing Science Demonstration shows may feature agriculture, however, and the Structures exhibit may have related content not obviously described on the website.

Of the smaller science centers sampled, overall nearly 60 percent of the exhibits are agriculture-related, even though none have the word *agriculture* explicitly in the title or short or long description. We also discovered that while smaller centers overall had higher rates of agriculture-related exhibits based on their titles and descriptions, the centers also tend to be more specialized. This meant there was a higher variation in the presence of agriculture-related exhibits among smaller science centers. For example, all the exhibits at the Ocean Science Exhibit Center at the Woods Hole Oceanographic Institute were agriculture-related due to the center's overall ocean focus. On the other hand, only one of ten exhibits at the New Mexico Museum of Space History was coded as agriculture-related, as that museum dealt primarily with space history and exploration.

The overall range of related content was very rarely explicitly related to food and agriculture. Instead, exhibits dealing with basic sciences or engineering, or applied fields such

TABLE 3. St. Louis Science Center example exhibit titles and long description excerpts

Exhibit	Long Description	Agriculture Explicit?	Agriculture-related?
Ecology and Environment	Observe as a tornado forms right before your eyes or feel the earth shake beneath your feet. Take a tour through Missouri's geologic past or journey to the badlands of Montana and dig for dinosaur bones. Peek into the world of paleontology at the Dana Brown Fossil Prep Lab and Dig Site.	No	Yes - Ecology
Experience Energy	Discover the power of the joule, see how energy becomes electricity and learn why energy efficiency makes a difference. Learn the different forms that energy can take, what physical laws govern energy and get a hands-on experience with generating electricity and building electrical grids!	No	Yes - Power
The Energizer Machine	Experience the wonder of simple machines working together in this amazing kinetic sculpture. Colored balls travel over 1/4 of a mile of track, going through loops, flying into nets, and more!	No	Yes - Mechanics
Structures	Learn about engineering and construction challenges and principles, from skyscrapers to bridges, highways and, of course, arches, in the Structures Gallery. Come prepared for a fully hands-on experience!	No	Yes - Engineering
Life Science Lab	The Life Science Lab is a space dedicated to educational programming, offering up unique and scientifically authentic experiences in the areas of genetics, biotechnology, agriculture, medicine and health.	Yes	Yes - explicit
Amazing Science Demonstrations	These fun and interactive shows have different themes every hour! Please check at CenterStage to see the schedule of demonstrations the day of your visit.	No	Can't tell

as biotechnology, were prevalent in the agriculture-related exhibits. Exhibits dealing with animals or plants broadly, including those about evolution, were found. There were also a number of exhibits related to skills of science research, such as observation, math, and modeling, which are fundamental to both science and agriculture research practice.

Discussion

Large science centers tended to be more evenly split between related and non-related content and covered a broader range of content overall. Small centers were highly variable, ranging from a large amount of agriculture-related content to none. Some small science centers were actually just a planetarium theater, which might show agriculture-themed shows about life in space but did not indicate that this was the case. Overall, however, there were definitely many exhibits that could be related to agriculture with some reframing of existing content.

Given the existence of content that could be re-branded without costly and extensive renovation, we suggest several ways that science centers could start to use their exhibits and programs to highlight the challenge the world faces of feeding 9.6 billion people by 2050; by addressing the existing exhibits and programs, science centers can immediately begin to make those traditional offerings more effective at engaging the public in social issues (Worts 2011). Some international museums, especially, already have programs and exhibits on agriculture ("Tapping into Agriculture" 2014). Others already focus on issues of sustainability (Worts 2011; "Spotlights" 2014), though they may not explicitly relate sustainability to food production or bridge to more traditional agricultural topics.

First and foremost, science centers can highlight their existing exhibits that are agriculture-related simply by connecting the word *agriculture* explicitly with programs and exhibits. This could be done by posting additional signs on exhibits or components or by creating field trips or public tours on topics of agriculture, either docent-led or self-guided. For programming both in the science center and traveling to schools, educators could redesign school programs to use agriculture as a context but offer similar hands-on explorations already in place. For example, a DNA extraction laboratory experience could be set up in the context of understanding how plants fight disease or in the context of genetic engineering to produce more nutritious products such as beta-carotene-enhanced rice. Similarly, science centers could partner with with local agriculture research colleges and industries as well as with science research entities to create a special event day or adult evening science café around agriscience issues.

Many science centers have already begun implementing various sustainability measures, which they may or may not make obvious to their visitors. These may include installation of solar panels, as at the Maryland Science Center, food partnerships and waste reduction through recycling and composting, as at ECHO Lake Aquarium and Science Center in Brulington, Vt., or smarter water use, as at the North Carolina Museum of Natural Sciences' Prairie Ridge Ecostation. These, too, can be directly tied to the problem of preserving resources for food production and distribution. Highlighting hunger problems that exist in the community gives these efforts a real local tie, making global, somewhat abstract problems such as climate change more relevant and motivating to individuals (Lachapelle et al. 2012).

Regardless of size, attendance, location, or operating budget, smaller science centers in rural areas have much to offer. This means teachers can use any science center to make Ag-STEM connections, even if they cannot travel outside their local area on a field trip. Science centers of all types can reach out to and work with agriculture and science teachers to encourage them to see these connections and offer their students a real-world problem as the context for their STEM learning, that of food production for our future population. They could market their professional development opportunities to a broader audience if they included agriculture teachers. If agriculture teachers consider the science centers as resources, they could work with center staff to find further connections between their curricula and the exhibits and programs. Botanical gardens, zoos, and aquaria have natural connections to agriculture based on their exhibitions of plants and animals and the related land use and resource needs, but these connections may be overlooked not only by agriculture teachers but also by the organizations themselves.

While we did not look specifically at agriculture, living history, or farm museums for their STEM-related content, we suspect that there are also existing exhibits in those museums that could be used to highlight Ag-STEM connections. These exhibits could be used, therefore, to talk about the challenges of feeding a growing population and the role of Ag-STEM research in addressing these issues, and the institutions could reach out to STEM teachers as a potential new audience as well. Moreover, agriculture museums and science centers could partner in these efforts, sharing each other's strengths and building even larger partnerships. University Cooperative Extension, for example, the nexus between agricultural research and public outreach in the Land Grant system, exists in nearly every county of the United States, not just in college towns or large cities (National Institute of Food and Agriculture 2015).

Conclusion

This article has explored the need for public engagement around research efforts for agriculture and agriscience—including global sustainable agricultural production, nutrition, hunger, and food and food security—and some ways that science centers can support these efforts. Adding agricultural context to science centers can emphasize Ag-STEM connections for both school children and the general adult public. Engaging the public directly in co-creation of content (Tate 2012), framing issues and moving people to action (Kadlec 2009), and thinking more broadly about a science center's mission and role in the community as related to food issues (Merritt 2012) will all help to address need for public involvement in meeting the long-term challenge of feeding a growing planet. At the same time, expanding the examination of food and agriculture can continue to serve more basic goals of public education and workforce development, particularly around Ag-STEM research.

The world is facing complex problems related to food that will require innovative agricultural science and STEM thinkers. Yet these thinkers cannot be fully supported in their efforts without communities that provide local input and develop a continual supply of well-prepared STEM workers. As science centers move to engage more with contemporary issues, they do not always need to completely overhaul their current operations to do so. With agriculture and food issues, the basic exhibits and programs often exist and may be addressed using a less costly re-framing and contextualization as a more immediate first step.

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About the Author

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NOTE: A new set of Agriculture, Food, and Natural Resources standards were released since original submission of this article. The career pathways used as reference for this study have not changed, but the new standards may be accessed at https://www.ffa.org/SiteCollectionDocuments/council_afnr_career_cluster_content_standards.pdf

Appendix: Sampled Science Centers

Large Science Centers [1]

Museum of Science and Industry, Chicago
Museum of Science, Boston
St. Louis Science Center, St. Louis
Liberty Science Center, New Jersey (Metro New York City)
California Academy of Sciences, San Francisco
Smithsonian: Air and Space, Washington D.C.
Smithsonian: Natural History, Washington D.C. [2]
Perot Museum of Nature and Science, Dallas [3]
Pacific Science Center, Seattle
California Science Center, Los Angeles
Franklin Institute, Philadelphia
Exploratorium, San Francisco
Smithsonian: American History, Washington D.C. [2]
Museum of Natural Science, Houston [4]
New York Hall of Science, Queens

Small/Medium Science Centers

University of Nebraska State Museum, Lincoln
The New Mexico Museum of Space History, Alamogordo
Children's Science Explorium, Boca Raton, FL
Woods Hole Oceanographic Institution, Woods Hole, MA
Tellus Science Museum, Cartersville, GA
Michigan Science Center, Detroit
Fairchild Tropical Botanic Garden, Coral Gables, FL
National Soaring Museum, Elmira, NY
Boonshoft Museum of Discovery, Dayton, OH
Buffalo Museum of Science, Buffalo, NY
Creative Discovery Museum, Chattanooga, TN
Dittrick Museum of Medical History, Cleveland, OH
Gheens Science Hall and Rauch Planetarium, Louisville, KY
Highlands Museum, Ashland, KY
History of Diving Museum, Islamorada, FL

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[1] The Fernbank Center in Atlanta was on the referenced list, but when we called to confirm, it was determined to have a smaller annual visitation and square footage than our threshold.

[2] The Smithsonian Museums are not part of ASTC, but we added these three due to their reputations and large annual visitation. The Museum of American History in particular has recently added exhibits on food and its history.

[3] The Perot Museum was too new to be included on the referenced list. It was added due to the desire to represent the Dallas-Fort Worth metropolitan area and its estimated annual visitation based on the previous science museum in Dallas.

[4] The Houston Museum of Natural Science is not a member of ASTC. It was added to represent the Houston metropolitan area and based on its annual visitation.

PROJECT REPORT

Deepening Understanding of Forest Health in Central New Jersey through Student and Citizen Scientist Involvement

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New Jersey Audubon Society

Jay Farrell Kelly
Raritan Valley Community College

Background

SENCER-ISE (Science Education for New Civic Engagements and Responsibilities-Informal Science Education) is an initiative funded by the National Science Foundation (NSF) and the Noyce Foundation to support partnerships between informal science and higher education institutions. SENCER-ISE currently includes ten cross-sector partnerships offering a range of civic engagement activities for K–12, undergraduate and graduate students, and the public. SENCER's primary focus is the improvement of undergraduate teaching and learning through the framework of civic engagement (Friedman and Mappen 2011).

While the formal and informal science education worlds seem far apart, Alan Friedman noted that "informal Science Education (ISE) does not deliver education like a school, but rather it provides opportunities for people to become fascinated with something they experience, and to then find themselves learning and becoming even more interested in whatever it was that caught their imagination" (Friedman 2011). This free-choice learning complements formal education. The goal of SENCER-ISE is to help students and the public appreciate the value of informal science education institutions as credible and accessible and to support the exploration of science, technology, engineering, and mathematics by people of all ages and all walks of life (SENCER-ISE 2014).

To achieve this goal and to emphasize the importance of informal science education, SENCER-ISE supports institutional partnerships between higher education and informal science partners./ Ten diverse partnerships across the United States are currently part of this program, with funding from the NSF and the Noyce Foundation. These partnerships are made up of an array of higher education institutions that include two- and four-year public and private colleges and universities and informal science education institutions that include science museums, an outdoor education center, a research and policy institute, and a wildlife sanctuary.

Civic engagement is the "acting on a heightened sense of responsibility to one's communities that encompasses the notions of global citizenship and interdependence, participation in building civil society, and empowering individuals as agents of positive change" (Musil 2009). By framing higher education in the context of real-world problems facing our communities, students more easily gain a sense of their studies' relevance and importance to their lives and the world around them, enhancing student interest and the imperatives both to learn and to take action. Moreover, by actively participating in identifying and solving these problems in their communities, students gain hands-on experience in applying what they learn, thus developing both the knowledge and practical skills needed to make them more informed, capable, and engaged citizens and professionals.

The Civic Issue

Funding from SENCER-ISE has been supporting a collaborative effort of New Jersey Audubon (NJA) and Raritan Valley Community College (RVCC) to monitor bird populations and forest health in central NJ in the Piedmont section of the Raritan River watershed. The goals of this project are to involve community college students and citizen scientists in a conservation issue of civic importance, and specifically to (1) document the abundance and distribution of forest breeding birds and the quality of their habitat in central New Jersey; and (2) make recommendations for improving forest health in the state.

Today, more acres of forests are being lost each year than any other land use type in New Jersey (45,000 acres were lost between 2002 and 2007 alone; Hasse and Lathrop 2010). Urban land uses have made the greatest increases and now cover nearly 30 percent of the state (1.5 million acres), propelled in large part by suburban sprawl. Significant strides have been made in recent decades to protect our natural areas from development through the public and private funding of open space, which has resulted in more than 1.2 million acres preserved. While these efforts have done much to stem the tide of habitat loss, little has been done to protect and maintain the quality of these natural areas in the face of other, more subtle threats.

In addition to the direct conversion of natural areas to developed landscapes, the integrity of the natural ecosystems that remain continues to be threatened by the physical and biological effects of fragmentation, including excessive deer herbivory, invasive organisms, climatic change, and pollution. New Jersey has some of the highest numbers and densities of deer and invasive plant species in the United States (Drake et al. 2002, Kartesz 2011). More than a third of the plant species present in New Jersey today are non-indigenous species (Snyder and Kaufman 2004), and many of these species

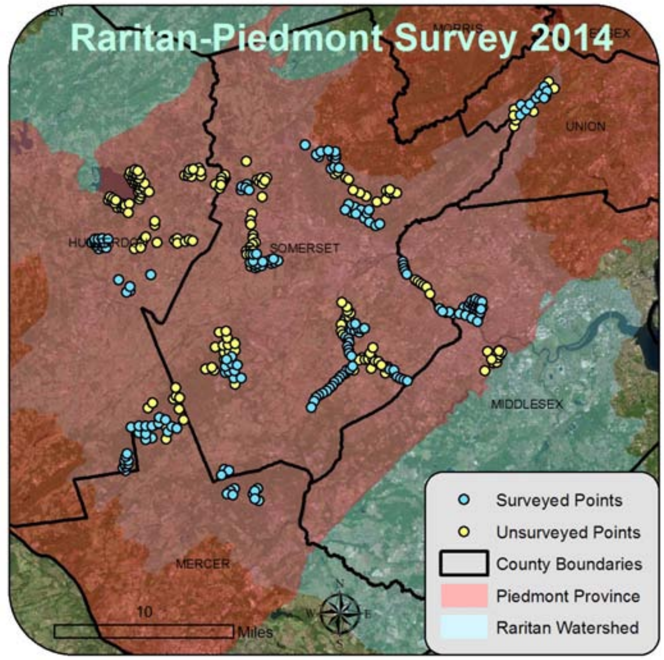

FIGURE 1. Map of surveyed area in NJ Raritan/Piedmont Region

are transforming our local ecosystems, filling in niches that are being created by disturbance and/or suppression of native species by deer. Deer densities in the state have been recorded at approximately twenty-eight deer/mi2 in recent years, which is approximately four times higher than the historical background rate. Densities of deer in central New Jersey are even higher, averaging seventy-eight deer/mi^2 and in some places as high as 202 deer/mi^2 (NJ Audubon 2012). The overabundance of deer has had devastating effects on forest understories, in which the herb, shrub, and sapling layers are completely absent in many places. The result is a slow process of ecosystem decay and the loss of many native species and habitat niches. Without intervention to protect, maintain, and improve New Jersey's natural resources, loss of ecosystem function and habitat is inevitable.

Program Plan

This project involves students and citizen scientists in collection of data on invasive plants and deer and bird populations. Students learn about the principles of forest ecology and conservation as well as applied research methods in their General Ecology, Field Botany, and Environmental Field Study classes. Following this immersive introduction to forest ecology, the students create materials to educate citizen volunteers about the impacts of deer overpopulation and invasive plant species on forest health, and to lead training sessions during which they teach the volunteers how to collect relevant data. After the training workshops, students conduct research on the status of selected forest areas, looking at deer browse and invasive species in those areas, all under the guidance of their RVCC professors and NJA staff. Funding from SENCER was sufficient to hire two interns for summer 2014. In addition, RVCC students raised $1000 in donations in spring 2014 and an individual donor gave RVCC $4,000 to support this program. With these additional funds, we were able to involve four interns in this program.

Concurrently, citizen scientists collect data on bird populations in those forests and at additional sites with the Raritan/Piedmont region and also made rapid assessments of invasive plant species.

Program Implementation

In spring 2014, Dr. Jay Kelly developed the Environmental Field Studies course at RVCC around issues of forest health and the specific SENCER project. Students were introduced to basic ecological concepts related to forest structure and composition and learned how these can be applied to understanding and assessing forest health. Students conducted extensive field and library research on factors such as forest history, land use, invasive species, deer overabundance, endangered species, climate change, landscape context, public policy, and forest management. After personally delving into the causes and consequences of these factors, students engaged in the development of solutions to these problems, focusing on integrating invasive plant species into the citizen science training being conducted by NJ Audubon, as well as assessing the effectiveness of existing restoration efforts and forest management plans being applied to local forest preserves.

Previous versions of the course focused on student-driven independent research projects and/or more structured modules, exposing students to the process of conducting scientific research (from literature review to various types of data collection, along with data entry, analysis, and interpretation) through a variety of less-directly related community-based field research and conservation/restoration projects (e.g., community well water testing, superfund sites, amphibian road crossing surveys, invasive and endangered species surveys). The new version through SENCER helped focus and deepen the course content, providing a useful conceptual framework to integrate different course materials and

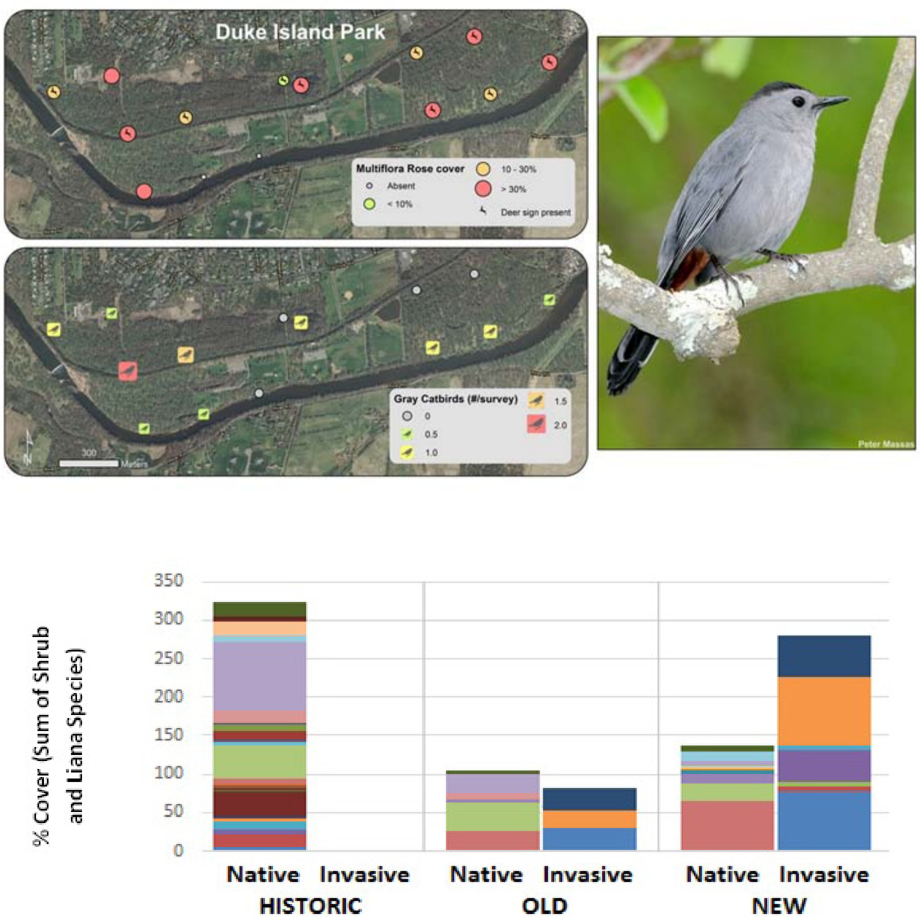

FIGURE 2. Sample data analysis of bird (top) and invasive and native vegetation (bottom) in the floodplain forest understory at Duke Island Park. Vegetation data compares "old" and "new" forest study sites to historic data sets from the 1950s.

giving students an opportunity to participate in meaningful community-based research and outreach being conducted by NJ Audubon. In all, this exposed them not only to the principles and practices of basic scientific research, but also to the relevance of research methods and results to solving real-world problems, and to the moral and civic values, roles, and responsibilities of science and scientists in matters of civic importance.

As part of the curriculum and syllabus, Kelly Wenzel, an educator with NJ Audubon, met with the students and helped them understand how to create lesson plans for volunteers and brainstormed with them on a design for a field manual. Dr. Nellie Tsipoura also spoke to the class as Director of the Citizen Science Program at NJ Audubon; she explained the purposes of the citizen science project and discussed what the students would be expected to produce and how to make the presentations tie in and flow with the rest of the workshop. Twelve species of invasive plants (shrubs, herbs, and emergent species) were selected as focal species for this project, and the students prepared materials on the biology and identification of these species. The students did a "dry run" of their PowerPoint presentations to the class during the lab period the week before the first citizen science workshop.

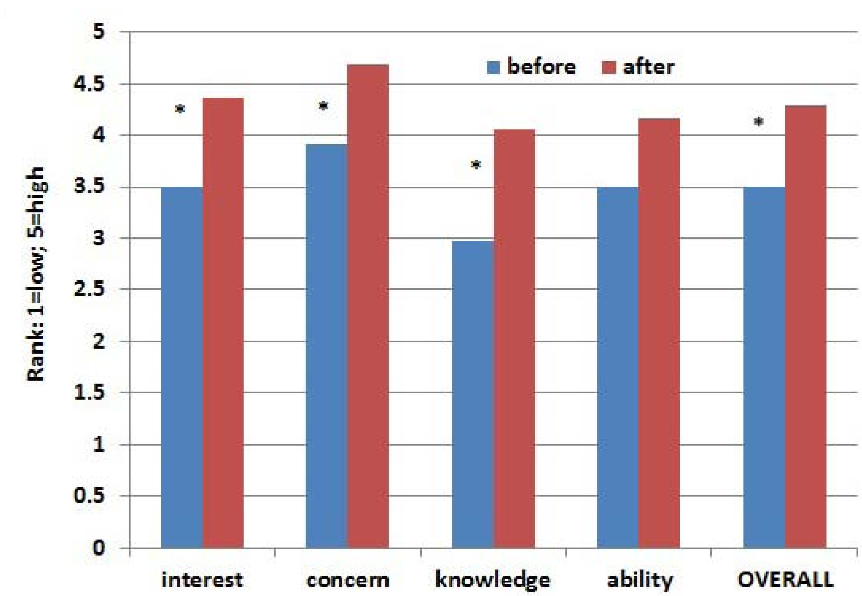

FIGURE 3. Self-assessment of students before and after participation in the project based on their response to questionnaires. Stars (*) denote statistical significance (GLM $p<0.05$). Interestingly, even though the rankings went up in every category, they were not significant for the "ability" related questions.

Citizen scientists were recruited through NJ Audubon membership lists and through birding groups in New Jersey. Although the NJ Audubon citizen science program has been active for over 10 years, creating new educational opportunities to engage and to challenge volunteers is a continuous process. The partnership with RVCC brings a fresh approach by allowing volunteers to interact with the college community and learn what the students are learning. In addition, people who have conducted bird surveys before through this project can expand their involvement and understanding of forest ecology by including the plant component, a new experience for them.

At training workshops, citizen science volunteers were presented with background information on the collaboration between RVCC and NJ Audubon through the SENCER grant. Then they were introduced to the purposes of the project and the scientific and civic questions relating to forest health in New Jersey. This was followed by (classroom) training in bird identification and invasive plant identification. While this is done in a classroom setting, we go into great detail concerning species identification with the aid of photos in a PowerPoint presentation, and in the case of birds there is also an audio component with bird songs. The bird ID part was presented by NJ Audubon staff, while the invasive plant identification was presented by the RVCC students.

The ID training was followed by a "working" lunch break, during which the students set up a display of herbarium specimens to test citizen scientists' newly acquired knowledge. The volunteers were excited about being tested and very pleased to realize that they could identify most invasive plant species correctly after the workshop. Finally, the last hour of the workshop was spent going through the protocols for data collection for birds (NJA staff) and invasive plants (RVCC). Since we are using rigorous scientific methodologies to collect data that can be used for conservation and management purposes, we impress upon the volunteers the importance of careful data collection and go into detail on what this involves.

Each citizen scientist received a packet with CDs of all the presentations and of bird songs, all the protocols, and any additional

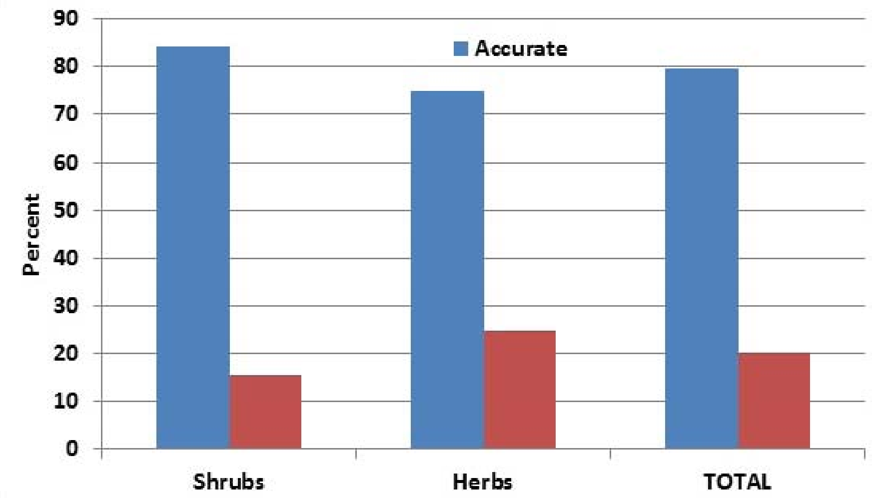

FIGURE 4. Percent of volunteer citizen scientist observations correctly reporting presence or absence of invasive shrubs and herbs

paperwork. For this specific project the students developed a "field manual" to assist with invasive plant identification and survey protocols, and this was also included in the packet. This field guide is two-sided with photos and ID tips for the invasive plant on one side and the similar native plant in the back, along with visual depictions of cover classes and search radii for different target species. Volunteers can cut them out separately or print them out again in thicker paper and develop cards that they can bring with them into the field (NJ Audubon Citizen Science Materials [http://www.njaudubon.org/SectionCitizenScience/CitizenScienceMaterials.aspx]).

After the workshop each volunteer was assigned five to ten survey points within the selected forest sites and conducted surveys of birds and/or invasive plants between late May and early July 2014.

Field trips and integrated curricula in the different courses prepared students for field data collection. The Forest Ecology Interns were taught basic plant identification and field techniques for measurement of forest structure and composition in their General Ecology (BIOL-231) class; rigorous experience-based field identification of New Jersey plants in Field Botany (BIOL-232); and background on forest ecology, historical human impacts, and present day threats in Environmental Field Studies (ENVI-201). However, the most essential course needed to qualify for the internships was Field Botany, since the interns needed to have adequate skills in plant identification in order to collect reliable data. Dr. Jay Kelly also gave them basic training and orientation in the field, helping to locate study sites, set up sampling grids, and identify any plant species that were unfamiliar to the students.

Results

Forest surveys

Overall 375 points throughout natural areas within the Raritan/Piedmont region were mapped and of these 192 points at seventeen sites were surveyed (Figure 1). Thirty-one volunteers participated in surveys and counted 3998 individual birds of eighty-eight species.

The interns collected data on the structure and composition of forest vegetation in the Piedmont region of the Raritan Watershed in central New Jersey, focusing on upland, mountain, and riparian environments and comparing forests of different ages, habitat types, and landscape contexts. Four student interns collected data at twelve sites (420 tree quadrats and 840 seedling plots) and counted 3067 trees.

While a complete analysis of biological information is beyond the scope of this paper and will be submitted to an ecological journal at the completion of the project, Dr. Jay Kelly involved the students in his fall 2014 General Ecology class in data analysis and presented the results at the RVCC Departmental Seminar. (See Figure 2 for examples of types of data and graphic representation and analysis.)

Student and Citizen Scientist Assessments

We conducted two types of quantitative project assessments.

To look at the educational value of the project for students, we distributed questionnaires to students before and after their participation in the program (Appendix 1). The questions asked for students' perspectives about their personal interest, concerns, knowledge, and skills related to both forest health and environmental issues in general. There were significant differences in obtained pre- and post-project scores overall and by category (SAS PROC GLM statistic; $P > F$ less than 0.05; Figure 3), with an average 0.8 point increase on a 5 point scale by each category.

To test the effectiveness of the training on volunteer citizen scientists' ability to identify and quantify invasive plants, we followed up and compared the results submitted by volunteers to the more accurate surveys that the student interns conducted at the same sites. We used similar methodology to that used by Jordan et al. (2012) and recorded true and false positives and negatives. After being trained, volunteers were very skilled at identifying invasive plants, reporting presence or absence correctly more than 80 percent of the time (Figure 4). However, volunteers were incorrect in their abundance estimates almost 50 percent of the time for shrubs, somewhat less for herbs. These results are similar to those previously published for invasive plant surveys (Crall et al. 2011; Jordan et al. 2012) and imply that we would need to incorporate a field training module to make those data more reliable.

Discussion

Participation in this project confirmed and strengthened students' interests in academic and career paths in environmental science and continuing civic engagement. The reflection papers show the impact this active learning experience made on these students not only in terms of approaching the civic issue of forest health, but also regarding learning and life in general (Appendix 2). All four summer interns in the 2014 program applied to do the internships again in 2015, in some cases turning down other more lucrative job offers to do so. All four students have successfully transferred to four-year programs in ecology-related programs at Rutgers and Cornell University, and several commented how well the courses at RVCC prepared them for their studies. This outcome of the project is in agreement with the studies of service learning that have found that students who combine community service and academic study benefit in their target attitudes, skills, and understanding of social issues compared to those who do not, as well as in their likelihood for further civic engagement (Eyler et al. 1997; Moely et al. 2002; Yorio and Ye 2011).

This project has benefited NJ Audubon, the non-academic partner, in its mission of protecting wildlife and engaging the public. To achieve conservation goals through citizen science requires an integration of volunteer involvement and conservation implementation (Figure 5). There are several steps in this process in which students can participate and contribute. In this project so far, these have included getting to know the audience, training participants, and tabulating and analyzing data. We anticipate continuing to involve students within the scope of the SENCER-ISE grant in disseminating results and reframing questions.

Furthermore, this project provides a model that NJ Audubon and similar nonprofit groups can use to engage college-age youth and help shape them into civic-minded citizens while promoting new skills and career directions. This model can be incorporated into future work, for example into grant applications and other fundraising activities, as a paradigm of informal education and successful involvement of youth. Currently, NJ Audubon and Brooklyn College, another ISE partner, are developing a new partnership with each other using this SENCER-ISE model. Student interns and class curricula will be supported through funds awarded to NJ Audubon for coastal impoundment and climate research that carries with it the requirement that young adults be involved in process. This project is in the initial stages of development, but since it is supported through a grant from the U.S. Department of Interior/Hurricane Sandy funds,

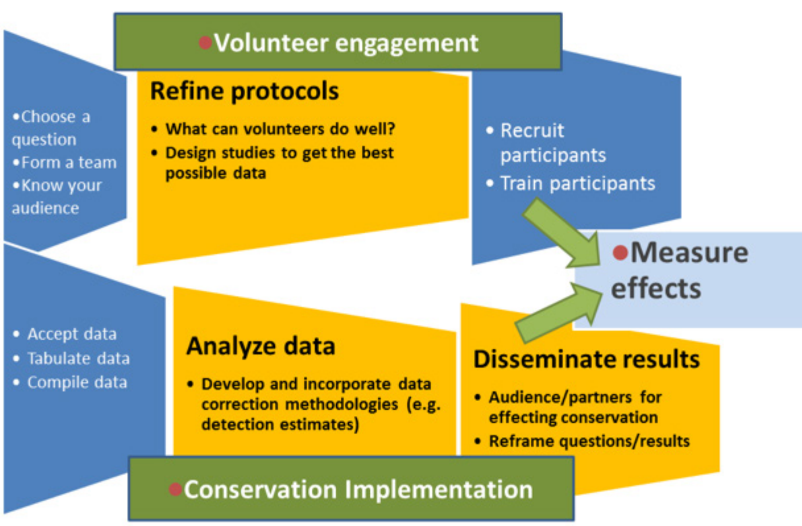

FIGURE 5. Schematic model of the process of involving volunteer citizen scientists in the effective implementation of conservation goals

it is likely to have high visibility and high civic impact. These opportunities for college students and other youth are becoming critical parts of conservation efforts as our understanding expands of how wildlife recreation and involvement in activities in nature results in pro-environmental behavior (Cooper et al. 2015).

Similarly, RVCC is building on our successes with the SENCER-ISE model, developing new partnerships with other non-profit institutions working on other types of environmental issues in New Jersey and abroad. These include a project being developed with Clean Ocean Action focused on plastic debris accumulation on the tidal portions of the state shoreline, and another with Pinelands Preservation Alliance related to beach management practices affecting endangered species habitat and dune development. Each of these projects will build on existing curriculum offered in the Environmental Science and Biology programs, research interests and experience of professors, and relationships with individuals at non-profit institutions who are involved with these issues, to develop opportunities to involve students in the research and outreach needed to help address these issues of civic importance in the state.

While scientists devise methods to test data reliability (Wiggins et al. 2011) and evaluate the information so that it can be used in conservation and management (Dickinson et al. 2012), less is understood about the longer-term impacts of citizen science activities on volunteers both educationally and in terms of attitude changes and continuing involvement in civic issues (Toomey and Domroese 2013) or about the motivations behind their volunteer work (Rotman et al. 2012). There is broad recognition that the processes and outcomes of citizen science need to be studied for their social, educational, and environmental impacts (Bonney et al. 2014; Jordan et al. 2015). Within the context of this project, we found that volunteers were able to identify plant species successfully, but were not very accurate at providing percent coverage estimates, suggesting lower order versus higher order learning for these two tasks (Bloom 1956; Miri et al. 2007). The information recall needed for species identification is an example of lower order thinking skills, whereas analysis, evaluation, and synthesis of information, considered higher order thinking skills, are needed for developing abundance estimates. Future work that includes a more in-depth look at the changes in volunteer knowledge and ability to conduct surveys, as well as changes in attitudes and motivation during a project, would contribute greatly to improving the informal education value of this approach.

Acknowledgements

We thank Ellen Mappen and Monica Devanas for many brainstorming sessions and fun discussions that resulted in this work; Hailey Chenevert for her help and support through the SENCER-ISE project process; all the SENCER-ISE partners for their input, suggestions, and camaraderie; Dale Rosselet and Kelly Wenzel for guidance on outreach and informal education; Mike Allen and Laura Stern for coordinating citizen science efforts and data collection; the RVCC students for their contributions to the training workshops and the field work; the many citizen science volunteers for collecting survey data; and NJ Audubon and RVCC staff for administrative support. Funding was provided by SENCER-ISE with additional support from the RVCC Foundation and Environmental Club and NJ Audubon donors.

About the Authors

Dr. Jay F. Kelly received his Ph.D. in Ecology and Evolution from Rutgers University in 2006. Since 2007 he has been a professor of Biology and Environmental Science at Raritan Valley Community College, where he teaches a variety of botany, zoology, ecology, and environmental science courses. His research interests are the ecology and conservation of endangered species in New Jersey, especially with regard to their population biology and habitat management. Other interests include plastic marine debris and toxins in consumer products and their effects on human health and local environments.

Nellie Tsipoura earned a Ph.D. from Rutgers University in 1999 and has been working as the Director of citizen science for New Jersey Audubon Society, developing and coordinating a number of studies that employ volunteers throughout NJ to monitor bird populations. Each year approximately 150 volunteers collect data on bird population that are used to make policy and management decisions. Through these citizen science activities, volunteers are provided a rewarding experience through informal education and civic engagement.

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Appendix 1.

Student questionnaire used to rank levels of concern, interest, ability, and knowledge. This was loosely based on the categories outlined in the 2008 American Association of Colleges and Universities rubric for assessment of students in civic engagement outcomes (http://bonnernetwork.pbworks.com/f/Fall+2008+VALUE+Civic+Engagement+Metarubric+Draft+for+Public+Release.pdf) and was modified by NJA Education Department for the NJA Conservationists of Tomorrow program. We further modified the questionnaire for this project.

	Zero/Very Low	Low/Below Average	Average/ Neutral	Above Average/ High	Very High
Concern about forest health					
Concern about invasive species					
Concern about deforestation					
Concern about deer overpopulation					
Concern about climate change					
Interest in forestry or forest management					
Interest in public outreach/education					
Interest in environmental policy					
Interest in forest ecology and related field work					
Knowledge of factors affecting forest health					
Ability to assess or measure forest health					
Knowledge of how to improve forest health					
Knowledge of plant identification and ecology					
Knowledge of animal identification and ecology					
Ability to make effective public presentations					
Ability to make a difference for the environment					

Appendix 2. student reflections and feedback

Here are some excerpts from RVCC student reflection papers. Students commented on their experience in the class through their service learning on invasive species with NJ Audubon and the SENCER project.

"The multiple ways that these topics were addressed was a huge help. Every time a new method was used it made it possible to gain a deeper understanding on the topic especially in a hands on way.

This opportunity has had a big impact on my life. This project and this class have opened my eyes to a multitude of things. I now realize that what I want in my life is to make a difference in the world. I want to take what I have learned about invasive/rare species and apply it to make a difference. I want to go and conduct studies and do everything I can to preserve both species and the ecosystems in which they live. This project has also inspired me to get more active in the community. On May 3, 2014 I am going to volunteer more of my time with the New Jersey Audubon to continue to help educate people on invasives. When I go and make a decision that will impact the community I look at what will be the best for the environment as a whole and not just I or a few people. I believe that whatever is the best decision for the environment is best for us all. The Earth is like a big boat, we are all stuck on it and if we destroy the only things we have got then we will be out of luck." – CS

"Receiving hands on experience with the information that I learned has definitely deepened my understanding of the issues of invasive species that were presented. I can learn all about the impacts of these plants in books, but personally seeing and experiencing the impacts of these species on forest health and seeing the great numbers that they are currently appearing in shows me a different part. It allowed me to physically see the effects of these species on my community and surrounding environments and that I can help and have a positive impact. Helping the environmental community is very important to me, and the 'hands on' work has been a very rewarding experience for me personally.

"Working outdoors with the environment directly will absolutely help me with my career. I plan on doing field work and endangered species conservation work in the future and this experience showed me all of the work that actually goes into a project. It showed me an accurate depiction of what kind of work I will most likely be doing for my career and enforced my decision for the career that I picked even more." – LP

"Seeing some of the environmental issues we face for what they are in real life, evokes a sense of urgency that would otherwise be lacking—doing something meaningful makes me want to do more. Teaching people in an effort to effect change to combat a problem was very rewarding. I enjoy sharing knowledge, especially meaningful knowledge, and through this opportunity, I have gained some experience in doing this effectively. Engagements of this kind are certainly something I would like to make a part of my future career." – AA

"The experiences in my Environmental Field Studies class [have] opened my eyes to think of topics that I didn't know about and it has made me realize the importance of topics that I didn't care about. As a result I have decided to begin hunting once again in order to attempt to keep the deer population in check, I have determined to try my hand at birding (although it seems like a daunting task to start!), and the class has led to focus my career goals on the importance of the conservation of our few remaining forests." – JS

"By having these engaging ways to learn all of these aspects throughout the course it was great to be involved and have a say, actually doing something rather than being lectured was a great change. By becoming active in these issues and being a part of the events this has given me a clearer understanding of my major and what may come of it, it makes me even more thrilled to be studying what I am knowing that this will be a part of my career. Being out there actually collecting data and seeing what we are learning about instead of reading about them makes me enjoy what I'm doing more [than] I have in the past. This experience has been so beneficial for me as an individual to now apply to my life. By learning what I have about forests alone and the effects that disturbances can have on them has made me think about every action I take. I do not look at forests, plants or animals the same, I have this new outlook that appreciates the balance set in place and how a single disruption such as invasive species can offset that and disrupt the native species. I now do not take for granted what is right in front of me because I now understand the importance of the smallest Swamp Pink or the amount of sediment flowing in a stream, each aspect has a role that can either enhance or diminish an ecosystem." – BP

"The hub for our new threads of information was certainly for me, the culmination of the Audubon project. To see all the pieces come together from our class incorporated into the Audubon's vault of knowledge and then passed along to the citizen scientists who will gather the data that could determine future forest health was not an end but part of a continuum for purposeful balance. I can see the interconnectedness of my role and the roles of my classmates play out tangibly in ways that I never would have noticed had we simply read from books and taken exams. The subtle artistry that was the curriculum employed by our professor to guide us through these realizations was nothing short of exquisite. I feel that our class as a whole has been able to glimpse a small fraction of the ecological long view that he integrates daily into his teaching and can now try our best to imitate in earnest.

"I can begin to see my particular strengths and weaknesses for what they are, helping me to sculpt a niche where I can be most effective in perpetuating forest health in my community. My desire to further my education in this field is stronger than before I began the project and I hope to remain as actively engaged if not more so in work outside of classroom theory for the duration of my schooling. My goal is not to passively wait for someone to award me a job upon graduation but to establish roots into as many areas of research, activism, and volunteerism that I possibly can to see where

I can grow most productively for the benefit of my community in my future endeavors." – RB

"The class as a whole deepened my understanding of sustainability. Knowing the past land usage in New Jersey deepened my understanding of the land I live on today. Seeing past land usage allows me to make sense of the situation our land is in today and why things are the way they are. The activities in this class also helped me learn the importance of education in spreading awareness of environmental issues. I also learned how important volunteering can be for gathering data about the environment and ecosystems in the state; the greater the number of people willing to help out, the better.

"In terms of my personal life, this term has encouraged me to become more involved in the community and to pursue more volunteer work. I'd like to volunteer to help gather data for projects such as citizen scientists or other Audubon society projects. I could even listen in on town meetings regarding environmental policy to get a better grasp of what's going on in terms of environmental care where I live. It's given me a greater awareness of what I as an individual can do to help." – LM

RESEARCH REPORT

From Generation to Generation: Incorporation of Intergenerational Informal Science Education into an Introductory College Science Course

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Abstract

Restoration of forest ecosystems following the loss of biodiversity associated with non-native species invasions is an issue of civic consequence that has the potential to engage audiences of all ages, backgrounds, and abilities. In this project, the strong sense of community connection felt toward a local forest preserve was leveraged to inspire native plant seed collection, propagation, and planting for a community-driven forest restoration project. As part of a larger project, informal science education was integrated into a general education environmental science course to engage college students in this civic project and in intergenerational community building. The introduction of students to informal science education (ISE) through collaboration with an outdoor education center was successful at increasing awareness of ISE as a potential career path, developing environmental science content knowledge, inspiring interest in restoration projects among elder participants, and building community. Intergenerational workshops resulted in bidirectional knowledge exchange among participants related to a strong sense of place shared by both generations.

Background

In 2013, a partnership between a small liberal arts college and an environmental outdoor education center was funded through a SENCER-ISE II grant to infuse civic engagement into informal science learning and integrate informal science education into higher education science teaching. During the first year of the grant work, college students, middle-school students, senior adults, and partnership institutions became an intergenerational community of practice centered around the critical issue of biodiversity loss through species invasions. The overall project included multiple components: young students collecting seeds of native plants, college students cleaning and propagating plants and initiating restoration research, and older community members participating in civic engagement activities related to restoration. The focus of this article is on the incorporation of informal science education methods into a general education, first-year college environmental science course using intergenerational learning and civic engagement. The intention of this portion of the larger project was to enhance student learning and promote community building by involving senior adults and college students in an intergenerational learning experience. The project combines aspects of informal science education with intergenerational learning and civic engagement. The project was designed to strengthen the link between environmental science learning and action (Ballantyne et al. 1998) by engaging participants in a topic relevant to their lives and involving them in interactive learning (Falk 2001).

Introduction

Informal Science Education and Civic Engagement

"Experiences in informal environments for science learning are typically characterized as learner-motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, and open-ended" (National Research Council [NRC] 2009, 11). In formal venues, learning is compulsory, structured, and teacher-centered, with content more central than social aspects of learning (Wellington 1990). Non-formal learning, a process that fits between formal and informal learning, is more structured but is more easily adaptable than formal education (Eshach 2007). The numerous definitions of informal, non-formal, and formal learning were recently reviewed by Stocklmayer et al. (2010). In this study, informal learning is understood as taking place outside of the classroom; it is learner-centered, includes both academic and social aspects of importance and, although it is not entirely unstructured, it relies to some degree on the learner's intrinsic motivations (Wellington 1990; Malcolm et al. 2003; Martin 2004). Research in teaching and learning in informal settings shows that, among other benefits, informal science education (ISE) is effective in increasing interest and engagement in science and increasing general scientific literacy, (Bouillion and Gomez 2001; NRC 2009; Stocklmayer et al. 2010), and that ISE is pertinent throughout a learner's lifetime (NRC 2009).

Because informal learning is personal and relevant as well as voluntary (NRC 2009), it is necessarily related to learning through civic engagement. In the spirit of SENCER, civic engagement is both personal and relevant, because society is replete with "wicked problems" that resist simple resolution and require interdisciplinary approaches grounded in civic responsibility (Lawrence 2010). In this sense, learning through civic engagement is similar to community-based service learning in that it is a meaningful connection between students and community, where students use new skills in real-world situations to serve their community. Experiential learning through civic engagement and tackling capacious problems takes this one step further; it exposes the interconnections that make problems "wicked" and promotes deeper learning on the part of both the students and the community. Service learning and civic engagement may be especially important in environmental education where there is a risk of leaving students feeling despondent and powerless as they learn more about environmental issues (Hillcoat et al. 1995). Service and civic engagement have the potential to awaken agency and empower students to make change (Bloom and Holden 2011).

Community-based service learning at its best encourages reflection that promotes civic responsibility, academic success, and personal growth (Arenas et al. 2006). Service learning increases awareness of environmental issues, conservation knowledge, enjoyment of nature, student motivation and engagement in school, and strengthens bonds between community members (Schellner 2008). Importantly, positive environmental attitudes and behaviors ignited through service lasted beyond the service-learning experience (Schellner 2008).

Intergenerational Learning and Community Building

The new generation of older people lead active lifestyles and have interest in future-oriented activities that promote personal fulfillment and social integration characteristic of the "active aging paradigm" (Chadha and Malik 2010). This project leverages the desire for continued lifelong learning and significant community involvement among elders to facilitate civic engagement through intergenerational learning. Intergenerational learning opportunities are most often defined as occurring with youth under age 21 and adults over age 60 (Kaplan 1997; 2002) and are common in fields of social and health sciences (Roodin et al. 2013). Intergenerational learning programs create intentional exchange of resources and learning among generations (Kaplan 2002). Importantly, intergenerational learning is based on reciprocity of benefit and thus is expected to be mutually beneficial for all generations involved (Ellis and Granville 1999; Tam 2014). Lifelong learning may be intergenerational but typically takes place in informal settings (reviewed in Broström 2003); thus, the articulation of intergenerational learning in informal settings is a natural combination with potential to enhance education and community connectedness.

Intergenerational learning programs have been successful with a range of age groups in a variety of venues, though most of the documentation of their success comes from students working in gerontology (Roodin et al. 2013). There were both curriculum and relationship-based benefits from a service-learning course in which college students worked with elderly participants (Tam 2014). Community elders working with primary school students (Peterat and Mayer-Smith 2006) showed cross-generational social learning and reciprocity of benefit. On a much larger scale, the Granddad Program in Sweden was successful at bringing senior adult male role models into schools as volunteers (Broström 2003). Many community-based intergenerational experiences focus on environmental activism, and seniors make especially good environmental steward role models because they possess the self-motivation for protecting the Earth for future generations (Ballantyne et al. 1998). When seniors were incorporated into a residential outdoor education program, children who worked with senior adults (as compared to the control group) gained more information on a wider variety of topics, and there was a trend toward improved environmental attitudes (Shih-Tsen and Kaplan 2006). In an ISE program, seniors were paired with students on an urban farm, and program participants showed increased environmental awareness associated with the experience (Mayer-Smith et al. 2007).

The benefits of intergenerational service learning programs are well documented (see reviews in MacCallum et al. 2006 and Roodin et al. 2013). Through bidirectional information flow including sharing life experiences and constructive knowledge exchange, participants increase their understanding of each other (Springate et al. 2008). Intergenerational learning programs or courses have the effect of reducing age-related stereotypes (Kaplan, 1997), with students reporting a more positive and appreciative attitude towards the older generation (Zucchero 2009 and 2011; Penick et al. 2014). Benefits to the elderly include benefits attributed to lifelong learning (Broström 2003): improved self-esteem and life satisfaction (Newman et al. 1997), physical, social and psychological as well as economic benefits (Tam 2011; 2014), maintenance of cognitive functioning (e.g., Ardelt 2000; Boulton-Lewis et al. 2006; reviewed in Tam 2014), and promotion of pro-social values (Broström 2003).

The benefits to youth from intergenerational learning are better documented than benefits to college students. Intergenerational learning experiences are reported to increase confidence and self-worth and improve practical skills among youth (MacCallum et al. 2006). Youth involved in intergenerational activities showed increased enjoyment in school, were less likely to become involved with drugs, displayed enhanced literacy development (MacCallum et al. 2006) and became more civic-minded and viewed their citizenship in more action-oriented terms (Kaplan 1997). Although many intergenerational service-learning experiences involve young children, working with college students has been shown to enhance the general well-being of older adults also (Hernandez and Gonzalez 2008). Our project adds to this literature by documenting bidirectional information flow and a sense of community belonging among college students and elders.

Project Description

Antioch College and the Glen Helen Outdoor Education Center (OEC) are situated in a Midwestern USA town of approximately 3500 residents, where the median age is 48 and the population is aging; approximately 47.5 percent of the population is aged 50 and older (US Census Bureau 2010). The College has approximately 200 students and very small class sizes. The OEC is within close walking distance to the college campus. Over 2700 grade school students and in-service teachers participate in educational programs that meet state teaching standards and are designed and led by a team of paid and trained naturalists at the OEC. The OEC is located within the city limits in a 1000-acre nature preserve (Glen Helen or The Glen) that receives over 10,000 visitors annually and is an important part of the local community.

We used the critical community issue of biodiversity loss to involve students and community members in forest restoration in the local nature preserve. The Glen encompasses a forest ecosystem negatively impacted by invasive species, most notably by bush honeysuckle. Bush honeysuckle has been documented to prevent growth of native understory plants through resource competition, allelopathy, and depleted soil seed banks (Cipollini et al. 2008; Cipollini et al. 2009; McKinney and Goodell 2010; Arthur et al. 2012; Bauer et al. 2012). Forests with invasions of bush honeysuckle also have lower amphibian species diversity and richness, altered patterns of pollinator visitation, song bird assemblages, and soil fungal communities, higher soil compaction, lower soil quality, and lack of certain other qualities that are indicators of a healthy forest understory (Watling et al. 2011). Restoration of forest ecosystems following invasive species removal is dependent on replanting native forest understory species and involves the consideration of numerous intertwined ecological principles that must be in place to sustain and promote the return and establishment of a biodiverse community (Vidra et al. 2007; Swab et al. 2008; Aronson and Handel 2011). Through this project, youth at the OEC, college students, and senior adult community members participated in the propagation of native plants for a forest restoration project in Glen Helen.

As part of our project, college students in the course entitled Introduction to Environmental Science visited the OEC, observed a naturalist-led hike, studied native and invasive species in class and in the Glen, and offered plant propagation workshops to senior adults at a local senior center. Workshops in which students participated were held in the "great room" at the Center, a large, open area. Eight tables with planting supplies were situated in a circle around the room and each table was attended by a student with a different native plant species to propagate. Chairs were arranged so participants could sit or stand at stations and there was ample room for moving from station to station. The workshop began with an introduction to the project, invasive species impacts, and restoration efforts in the Glen. Then participants were encouraged to help clean or plant seeds at any of the stations and to move among stations. The effect was to optimize personal, intergenerational interactions in an experience with direct relevance to people with some connection to the Glen.

The objectives of this curriculum innovation were to

1. Introduce students to informal science education (ISE) as a potential career path
2. Teach content knowledge related to invasive species and biodiversity loss
3. Design and implement an intergenerational learning opportunity that results in bidirectional knowledge sharing

The workshops were designed to engage older adults and college students in meaningful work and ultimately create a sense of community purpose while encouraging environmental responsibility and civic engagement. This type of community connection through active civic engagement promotes the personal fulfillment and social integration sought by elder community members (Chadha and Malik 2010). College students benefit from working with adults of a different generation and forming ties that spill over and enhance community life (Roodin et al. 2013).

Methods

There were two primary activities in the curriculum design; one introduced students to ISE and the second put the students into the position of informal science educators in an intergenerational workshop. We scaffolded the student-led workshops by introducing students to the OEC and having them observe and reflect upon an informal science lesson. The class walked to the OEC at the beginning of the quarter to meet the Director, tour the facility and discuss OEC programs. During the quarter, students were required to attend one naturalist-led hike, observe the lesson, and submit a reflective assignment within two weeks of completing the hike. The reflection activity included a description of the lesson, suggestions on how to improve or extend the experience, and thoughts on the importance of ISE in education. Two weeks before the workshops, students participated in class work that introduced them to the project, biodiversity, and issues related to invasive species. They chose a native plant (from a list of those available) and completed individual research on the natural history of the plant. Students designed and printed an information sheet on the species and were told to be prepared to describe their species and the project and to answer questions during the workshops. They submitted the species information sheet for feedback and grading before the workshops. Students were divided into two groups to offer two workshops at the local senior center during February 2014. In the workshops, students managed their own "propagation stations," provided information on their native plants, and cleaned and planted seeds with workshop participants. Students learned seed cleaning and planting before the workshops in a separate classroom activity.

Students taking the class in fall 2013 participated in the naturalist-led hikes, but workshops were offered only during winter 2014 quarter. Thus, included here are two sets of student reflections on OEC involvement and one set (winter quarter) of workshop assessments. Student responses to an open-ended question on the hike reflection assignment were coded using presence/absence codes based on the assessment prompts (Table 1). Codes included experience (positive or negative), expressed interest in ISE (yes or no), and recognition of ISE as important to the student's education (yes or no). Two additional codes were added to the analysis of the winter quarter reflections: awareness of ISE before the class (yes or no), and whether or not students noted learning something that they previously did not know about ISE (new learning). To further quantify interest in ISE, students were asked in 2014 if they were interested in a cooperative working experience (co-op) as a naturalist assistant. They could answer yes, no, or maybe and were asked to provide an explanation of their choice. Given the presence/absence format of codes, there was very little room for interpretation. A second coder, unfamiliar with the project, coded the same student responses; the inter-coder reliability, calculated as the proportion of individual excerpts and codes that the individual coders applied similarly, was 95 percent.

To assess knowledge sharing and community building during the workshops, students completed workshop reflection sheets, and older adult participants were asked to complete a post-workshop survey before leaving the Senior Center. Before the start of the workshop, students were asked to keep a tally of the number of participants with whom they interacted and to remember conversation topics. Students completed the reflection sheet immediately at the end of the workshop. The survey for older adult participants included ten statements with 10-point anchored responses that ranged from 1 (not at all) to 10 (very much or a great deal) with the prompts "How much did this workshop…" and "To what degree…" and a space for additional comments.

Four exam questions were used to evaluate student content knowledge about biodiversity and invasive species: (1) What are the five major threats to biodiversity that we discussed in class? (2) What is the number one cause of the loss of biodiversity on the planet? (3) Outside of bush honeysuckle, what are two additional examples of invasive species that are negatively impacting ecosystems in the USA? (4) Bush honeysuckle and other invasive plants impact native plants by shading, competition for space and soil nutrients. Describe two additional negative impacts that this invasive has on natural ecosystems (outside of impacts on plants under the honeysuckle). In addition to these questions, students were asked to rate the extent of their knowledge about bush honeysuckle as an invasive species compared to their knowledge before they started the class. Answers were on a five-point Likert scale ranging from none to very high.

Results

Naturalist-led Hikes

Students who attended their required naturalist hike and submitted a reflection assignment all provided adequate descriptions of the lesson and responded to additional questions appropriately. This indicated that the students attended and engaged in the lesson. Students had an enjoyable experience at the OEC, expressed interest in ISE, recognized the importance of informal learning opportunities and in most cases were interested in additional ISE experiences. Some students noted that the cold weather was the only aspect of the experience that they did not enjoy, but 100 percent of students in both classes described positive experiences overall.

Some students began with an interest and strengthened or acknowledged that interest, whereas others gained interest in ISE through their participation in the hike at the OEC. Interest ranged from very interested to no interest (Table 1) and, 86 percent (fall) and 87 percent (winter) of students expressed interest in ISE. Students who expressed interest in ISE, recognized ISE as a potential career path and a way to garner teaching experience. One student wrote, "…I am very interested, in fact, that is what I hope to do as a career." Another wrote, "I am definitely interested in informal science education…. Even if I do not choose being an educator in my profession, I will probably run into a situation where I will be teaching in some way, and informal education can be a great option to handle this opportunity." One student was interested in education but not specifically informal science education: "…I am somewhat interested in education as a possible career. I'm not entirely sure if informal science education would be the specific career path…." For some students, their experience at the OEC led them to reconsider ISE: "Before this hike I would not have believed I had any interest in informal science education [;] however now I believe I might," whereas another student, even after this experience, was "still not very interested in informal science education … I have other things that I want to do." It is not possible to determine whether the lack of interest was because it was specifically science education; none of the students were science majors.

In 2014, when asked about interest in a co-op work position as a naturalist assistant, of the twelve students who replied, only two gave a negative response; the others chose either yes or maybe. The two students who were not

TABLE 1. Prompts for college student reflection about their experience on a naturalist hike at the outdoor education center

Class	Prompt
Fall 2013 (n = 15)	"Write a short paragraph about your experience with the OEC. Include whether or not you might be interested in informal science education and how informal science education has been or may be important to your education."
Winter 2014 (n = 12)	Same text as above with the following addition: "Were you aware of environmental education/informal science education as a career before this exercise?"

interested explained their response by their lack of knowledge in science, lack of interest in working with children, and the need for experience related to their non-science major. Although these two students did not recognize how this experience might benefit them regardless of their major, another student commented, "I would say it'd be a better fit for an environmental science major, or someone who has a bigger interest in being a teacher someday! However, I think it'd be a good experience to have and I would consider it!" Two students who chose "yes" and one who chose "maybe" specifically tied their response to their positive experience on the naturalist-led hike.

Almost all students in both classes (87 percent in fall and 100 percent in winter) provided anecdotes describing the importance of informal learning to their education or, more commonly, in educating youth in environmental science. Many students provided examples of their own positive experiences with informal science education at their grade and secondary schools and through interactions at nature centers. No one described a negative experience with informal science education, and most were very interested in the "outdoors," and especially in learning more about the specific nature reserve used in this project.

Among the students who described themselves as previously aware of informal science education (86 percent, n = 7, in winter quarter), five of them described how their view changed after the hike. Two admitted that before their experience in the class, they had different concepts of what it meant to work in informal science education (e.g., park ranger). Two students gained appreciation for ISE: "…I never knew how amazing it was" and "Before this hike I knew what informal science education was but I never really considered it as one of the career paths…." One became aware of the OEC for the first time and another gained awareness of the importance of naturalist jobs: "Looking back however I can understand the importance of her [the naturalist's] job and of other careers such as hers."

Increased awareness was often tied to "new learning" about ISE. Although the assessment prompt did not specifically ask about new understanding, half of the students in the 2014 class indicated that they learned something new about ISE through their experience. For example, one student commented, "Visiting the OEC gave me a different perspective on the types of education I might be suited for or interested in" and another, "I had not thought very much about a career in informal science education but now I definitely see how important it is to teach young ones about nature."

Senior Adult Workshops

The workshops received very positive reviews from students and adult participants. The reflections that the participants provided on the surveys indicated that the workshops facilitated bidirectional sharing of knowledge across generations and a sense of community building. One shortcoming of the workshops was that they occurred during a particularly cold and snowy winter, which limited attendance by senior adults. There were eight students at each workshop and twelve adult participants at the first and only six at the second workshop. Not all participating adults chose to complete a post-workshop survey, and so, our sample sizes for adult reflections are low. The structure of the workshops encouraged adult participants to move from station to station and interact with several students. Thus, although the number of participants was low, all students had the opportunity to engage with multiple participants during the course of the workshop.

Bidirectional Knowledge Sharing

Post-workshop surveys completed by students showed that on average, each student shared their knowledge of native plants with four adult participants and, on average, three older adult participants shared knowledge with the student. Students listed the types of information that they shared with adult participants, which included information on the plant's habitat, pollination, use of natural insecticides, forest understory, mesic wetlands, similarities to other plants, planting methods, germination requirements, types of plants (herbaceous and woody), and invasive species impacts. The responses indicated that students were synthesizing and sharing what they had previously learned in class as part of this project or other class activities.

The examples that students provided indicated that participants shared their knowledge of plants as well as general knowledge about a wide range of topics. Students commented that they learned about tree diseases, organic gardening methods, the history of the Glen, how to recognize some native flowers, and how seeds are dispersed. Adult participants were sharing their expertise with students while the students shared information with them. For example, when asked to provide examples of knowledge shared by participants, students wrote

> *"One woman talked about the dogwoods she had…."*

> *"…the paw paw festival and different kinds of paw paw cultivation…"*

> *"…the trees [she] saw in the Glen…"*

> *"past/current gardening experiences, talking about their lives in general…"*

> *"…The seeds are long because they can be carried easier by the wind…."*

> *"…got a great book recommendation" and*

> *"I feel like I learned a lot from those who visited my station."*

Sense of Community

Student reflections revealed a positive sense of community connectedness. For example, some student responses to the prompt "How did the experience influence your connection to the community (outside of the campus community) and connection to the Glen?" included

> *"It felt good to chat with community members and to see how they feel about…"*

> *"I loved to meet members of the community … and get to hear their stories."*

> *"I was able to make connections based on common interests"*

> *"…It made me feel more connected and more open to the community.…"*

> *"I felt more strongly connected to both the Glen and the community, particularly because we took action to improve the Glen with the help of the community."*

And several students indicated a desire to become more involved in the community:

> *"…encourage me to reach out more to the community at large; they are awesome!"*

> *"I would like to … be more involved with the Yellow Springs community."*

Among the eighteen adult participants in the two workshops, only 14 elected to complete a survey. The highest rated survey questions were "To what degree did you enjoy interactions with students?" and "How much did this

FIGURE 1. Average scores from senior adult workshop participant responses on post-workshop surveys. (n = 14)

workshop increase your interest in getting involved further in Glen Helen restoration efforts?" (Figure 1). On average, all responses were over six out of ten possible levels and indicated an overall satisfaction with the workshops. Interestingly, older adults did not feel that they shared their knowledge with students to the same degree that they increased their own knowledge and that students shared with them. This is contrary to the student's description of knowledge exchange and appreciation for information shared by older adults. Older adult participants liked the degree of interaction possible in the workshop and expressed a stronger personal connection to the community as a result of their participation.

Content Knowledge

Exam questions for students in the environmental science class were graded as "all or none" to assess content knowledge. Fourteen students completed the four assessment questions included on their exam in winter 2014. Among those 14 students only two described their prior knowledge of honeysuckle as an invasive plant as high and both of these students had some experience working with invasive plant removal in the Glen through other opportunities. All students identified the most common cause of biodiversity loss and correctly listed invasive species in addition to bush honeysuckle; 93 percent were able to provide additional negative impacts of honeysuckle on an ecosystem, and 86 percent correctly listed five threats to biodiversity. Despite their perceived initial lack of knowledge about honeysuckle as an invasive species, students gained knowledge about invasive species during the course of the class activities.

Discussion

Students increased their understanding of informal science education, biodiversity, and invasive species impacts and strengthened connections to the local community through participation as informal science educators in intergenerational plant propagation workshops. The naturalist-led hikes provided students with concrete examples of informal science education in action and appropriate scaffolding for stepping into the role of informal science educator. Students and senior adults alike were extremely positive about the workshops, and within the workshops there was successful bidirectional, cross-generational information sharing.

Student participation in naturalist-led hikes as an introduction to ISE was successful at stimulating interest in and increasing awareness of ISE as a potential career path among college students. This project focused on increasing awareness of the OEC as a local environmental education resource and the potential for students to participate in ISE as part of their science career. Other studies have shown that students' career planning was enhanced and that they changed their beliefs about careers following short summer programs (Barnett et al. 2011). Anecdotally, there is an indication that the interest in ISE persisted among students: one student applied to the OEC for a paid naturalist position.

The combination of ISE, intergenerational learning and civic engagement with college student participants is relatively unique. Informal science education programs at museums or zoos (NRC 2009), for example, are generally designed for unidirectional knowledge flow from an educator to a diverse public audience. Many intergenerational learning programs at the college level are situated in gerontology programs and often these programs neither promote nor are designed for bidirectional knowledge exchange (Roodin et al. 2013; Tam 2014). Such programs are more correctly deemed multigenerational rather than intergenerational (Tam 2014). In the case of this project, workshops were truly intergenerational, and bidirectional knowledge sharing was easily documented. Sharing of knowledge between students and older adult participants suggests that academic knowledge was in no way privileged over community knowledge (Trickett 1997), and this epistemic equality promoted knowledge flow and, most likely, community connectedness.

Community building as an objective of informal science education and intergenerational learning is based in the theoretical framework described as tapping in to "funds of knowledge" (Basu and Barton 2007). These "funds" are the cultural and historical knowledge residing in the community. Communication of this community knowledge may enhance science education by making science more relevant to the lives of students (Basu and Barton 2007). In this project, intergenerational workshops were described by students as strengthening community connectedness, and the appreciation that students expressed for the knowledge shared with them by senior adults appeared to enhance this community connection and support the overall positive evaluation of the experience.

The success of intergenerational experiences in the context of civic engagement is dependent in large measure upon choosing a critical issue whose approach serves both the public and academic communities. For this project, it was the connection to place, Glen Helen, that was a driving force for a successful program. Place-based experiential learning has been shown to enhance undergraduate student content knowledge in the plant sciences (Bauerle and Park 2012) and influence individual agency related to environmental issues (Rodriguez et al. 2008; reviewed in McIreneny et al. 2011) and public participation in science (Haywood 2014). Glen Helen is a valued resource in the community, and satisfaction with the workshops was related to the perception that older adult participants were helping the Glen. Workshops also stimulated interest in being involved with Glen Helen restoration projects, and student reflections on the naturalist-led hikes indicated an interest in learning more about Glen Helen.

Students demonstrated an understanding of content related to invasive species, biodiversity, and native plants on an exam, but more impressively, students communicated content knowledge to adult participants in workshops. Communication of their knowledge to community members indicates that students have some confidence in their abilities and understanding of science. When graduate education students assumed the role of informal science educators, they honed communication skills and increased their confidence in using skills and knowledge gained in the classroom (Crone et al. 2011).

The success of the workshops and the project overall can to some degree be attributed to the consideration of recommendations from previous research on intergenerational service learning. In general, students benefit from authentic learning and participatory experience coupled with structured reflection (NRC 2009). This was incorporated into the project in the form of an educator-community partnership rooted in a civic issue relevant to the lives of participants. Intergenerational ISE programs are best when they incorporate opportunities for significant personal interaction (Fenichel and Schweingruber 2010), something that the senior adults prized about their workshop experiences. It is also important that there is a potential for one-on-one interactions and that programs proceed at a leisurely pace (Shih-Tsen and Kaplan 2006) and take into consideration the mobility or limitations of participants. This project offered student-led workshops that had all of these characteristics.

Shortcomings of the project are primarily related to the low participation by older adults and the lack of a control group. Attendance at the workshops was complicated by poor weather, and this is especially pertinent for older adults who may experience decreased mobility. Winter was chosen as the best time for propagation workshops based on the college schedule and conditions needed for germination and establishment of plant stock for the restoration project. Thus, there was a trade-off between appropriate conditions for participants and logistics imposed by the academic and research schedules. Why some senior adults chose not to complete a survey is not clear. Also, it is not possible to know whether student content knowledge was enhanced as a result of the intergenerational interactions, because there was no control group for comparison. Additionally, because some assignments were graded, it is possible that some student responses lack sincerity, but we have no way of knowing whether this is true. Despite low numbers, results indicate a very positive response by both students and adult participants that is sufficient to warrant scaling up the project.

Whether the benefits of the experience are long-lasting or coupled with increased environmental activism is unknown but an interesting question for further research. Civic engagement tends to increase among students who participate in service learning with older adults (Hegeman et al. 2010; Karasik et al. 2004), and these interactions with a larger community may influence personal ecological identities (Morris 2002). Thus, it is possible that programs that combine ISE, civic engagement, and intergenerational learning yield benefits far beyond those documented for this project.

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About the Author

Linda Fuselier is faculty in the Biology Department at the University of Louisville where she is responsible for the redesign of a large enrollment, non-majors biology curriculum. Before moving to Louisville, Linda was at Minnesota State University, Moorhead where she was Biology faculty and Director of Women's and Gender Studies. At MSUM, she worked with biology faculty to infuse research into the undergraduate curriculum and formed an interdisciplinary team of faculty tasked with infusing the SENCER approach into biology, physics and Women's Studies classes. Her current research involves creating SENCER-based modules using contemporary women's issues and designing curriculum materials for science information literacy.

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RESEARCH REPORT

Persistent and Encouraging Achievement Gains on Common Core-Aligned Items for Middle School English Language Learners:

ASAMI— Hands-On Astronomy for After-school Science and Math Integration[1,2]

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Abstract

ASAMI—*Afterschool Science and Math Integration*—integrates skills of mathematics with interesting concepts and hands-on activities in astronomy-based science in the middle school. Common Core Mathematics Standards and Next Generation Science Standards (NGSS) are used as ASAMI effectively teaches algebra standards/concepts with Hands-On Universe (HOU) curricula to engage 12–14-year-old English Language Learners (ELLs). In our 2014–15 school year pilot and field tests of ASAMI, students classified as ELL met twice a week for a total of four hours a week at a middle school in California, USA. The evaluation of ASAMI shows that these learners improved their test scores on Common Core Mathematics Standards-aligned items [Gain = (post-test–pre-test)/pre-test] by 46 percent in our first six-week trial and by about 93 percent in our second semester in the school year. Two other pilots resulted in similar gains. The main algebraic focus and assessment items focused on ratios, proportion, and linear equations, which are used throughout the curriculum of the HOU. Our assessments show that ASAMI is a very effective tool to help focus instruction, and students demonstrate success in learning through the integration of mat h and science. While the desire for integrated math and science curricula has been expressed for decades, few quantitative studies of achievement gains have surfaced (Czerniak, et al. 1999).

Background and Introduction

Hands-On Universe

Afterschool Science and Math Integration (ASAMI) is based on Hands-On Universe (HOU) astronomy activities that are often computer/technology based. HOU was based for many years at the Lawrence Hall of Science (LHS) at the University of California, Berkeley, and developed significantly within the Hall. Alan Friedman's leadership at LHS in astronomy education help build the discipline of "Hands-On" astronomy. HOU has many linkages directly traceable to Alan, and the appendix describes the heritage of HOU through Alan.

Over its almost 25 years of activities, HOU has brought the wonder and the data of the Universe into classrooms all around the world. Approximately one thousand American teachers have been in HOU teacher workshops. Through the Galileo Teacher Training Program (GTTP), approximately 20,000 teachers in 100 nations around the world have been in HOU workshops. Formal external evaluations submitted to the U.S. National Science Foundation have usually demonstrated that HOU changed students' attitudes positively towards STEM careers and helped students appreciate math, science, and technology. In HOU students measure objects on and off the computer and make models of celestial systems. We currently plan to start a new round of United States HOU Teacher workshops and are actively seeking funding. ASAMI is the most recent version of HOU. It uses HOU's images, software, activities, and methods, adopted for English Language Learner (ELL) middle school students.

Program Goals

One goal of ASAMI is that students master enough math so that they can explore careers in STEM fields. Our pretests of the ELL students demonstrated that these students were lacking important skills and would have difficulties pursuing STEM careers. All citizens of the world are now facing major technological and scientific challenges. Every student needs to become an active, well-informed and educated citizen. The ELL students in our study required some additional interventions in their education to succeed in the disciplines of math and science. We wanted these students to to engage in and appreciate math and science, using HOU-inspired activities, both on and off the computer.

NGSS Middle School Topics

The Next Generation Science Standards (NGSS) recommend that science education in grades K–12 be built around three major dimensions: scientific and engineering practices; crosscutting concepts that unify the study of science and engineering through their common application across fields; and core ideas in the major disciplines of natural science (http://www.nextgenscience.org/three-dimensions). *The Framework for K-12 Science Education* (Quinn, et al. 2012) also identifies seven crosscutting concepts that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. Among the seven crosscutting concepts presented in Chapter 4 of the *Framework* is the following: "Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance." (p. 84)

The first three standards of Middle School - Earth Science Standards of NGSS (NGSS, 2013) support well our objectives in ASAMI:

1. MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]
2. MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as their school or state).] [Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]
3. MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences

among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]

Such topics in the NGSS were included in ASAMI and were found in all of the activities. (See Appendix 2.)

Common Core Seventh- and Eighth-Grade Math

The NGSS clearly require the inclusion of the mathematical concepts of scale and proportion. Meanwhile the State of California has also adopted the Common Core Mathematics Standards,which include, for grade seven: "Analyze proportional relationships and use them to solve real-world and mathematical problems," and for grade eight: "Understand the connection between proportional relationships, lines, and linear equations." Many middle school students have had difficulty in understanding these concepts. The Trends in International Mathematics and Science Study (TIMSS) reports: "Students also found the proportionality items difficult. For example, one of the least difficult problems in this area asked about adding 5 girls and 5 boys to a class that was three-fifths girls. On average, fewer than two-thirds of the students across countries correctly answered that there would still be more girls than boys in the class" (Beaton 1996,3). Such students are subsequently unable to achieve mastery of algebra, the gatekeeper to more advanced mathematical and scientific courses. Research referenced in this article shows that an integrated curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for learners.

Target Audience

ASAMI had its first pilot study done at a diverse middle school in El Cerrito, CA, during 2012–2013. Then the leaders of ASAMI identified three middle schools in Hayward, CA, as appropriate schools for collecting research data about its effectiveness. The principals of these schools wanted ASAMI to serve their many students who are English Language Learners. Table 1 below indicates that ELLs are a significant segment of learners in California overall and in Hayward in particular. Our pre-tests indicate this population is very challenged to master the standards of Common Core Mathematics.

To meet the needs of the English Learners, the ASAMI program included several tutors who are bilingual in English and Spanish. Although the lessons were taught in English, the tutors were always available to help the English Language Learners to understand the assignments and to feel accepted. Here are data from Ed-Data of California from the year 2013–2014:

TABLE 1. Demographics of Schools in Target Area

School or Educational System	Hispanic or Latino Students	English Language Learners	Free or Reduced Price Meals
California	53.3%	22.7%	59.4%
Hayward Unified School District	61.1%	30.9%	70.5%
Winton Middle School	76.9%	22.2%	78.9%
Bret Harte Middle School	51.1%	10.1%	67.8%
Cesar Chavez Middle School	67.3%	27.8%	81.1%

The ASAMI program provides all of the hands-on materials and often sends the students home with items they constructed. Leaders at the schools help greatly by recruiting the students, monitoring their attendance, and phoning the parents of absentees. From interviews (to be published), it was very clear that parents want their children to succeed in STEM and are eager to cooperate with this after-school

FIGURE 1. ASAMI Student at Work

program. Our interviews indicate that many English Language Learners struggle to learn a new language and simultaneously keep up with the pace of study in the classroom.

M. Calderon (2007) has stated: "The Hispanic dropout rate is the highest in history." We have observed that ELL students often become discouraged, fail to compete, and are ready to drop out of participation in school activities. The ASAMI program is achieving a caring, enjoyable environment where the students are making progress.

Fry observed: "An analysis of recent data from standardized testing around the country shows that the fast growing number of students designated as English language learners (ELL) are among those farthest behind" (2007, i). The ASAMI project has been used successfully to serve this needy population. The faculty of ASAMI have endeavored to use the best practices (Rolstad, et al. 2005; Short and Echevarria 2004) to serve these students. Many of the previous studies tended to focus on language acquisition. The ASAMI program adds the acquisition of science and math to the literature. Integrating inquiry-based science and language learning brings success to ELLs, according to Stoddart, who wrote: "The authors of this article take the alternate view that the integration of inquiry science and language acquisition enhances learning in both domains" (2002, 664).

ASAMI Activities

Table of Some ASAMI Activities

An exemplary list of ASAMI activities is shown in Appendix 2. Each activity usually required one to two hours in an after-school session.

Modeling Pedagogy and Support of the NGSS Practice Matrix

ASAMI endeavors to implement at the middle-school level the Modeling Pedagogy, which is widely used in many high-school physics classes. The lead ASAMI teacher, Jennifer Perazzo, uses these instructional strategies. Moreover, creating and evaluating models is a major goal of NGSS.

The website of the American Modeling Teachers Association explains: "Modeling Instruction . . . applies structured inquiry techniques to the teaching of basic skills and practices in mathematical modeling [and] proportional reasoning" (http://modelinginstruction.org). Modeling Instruction has proven to be one of the most reliable pedagogies to improve

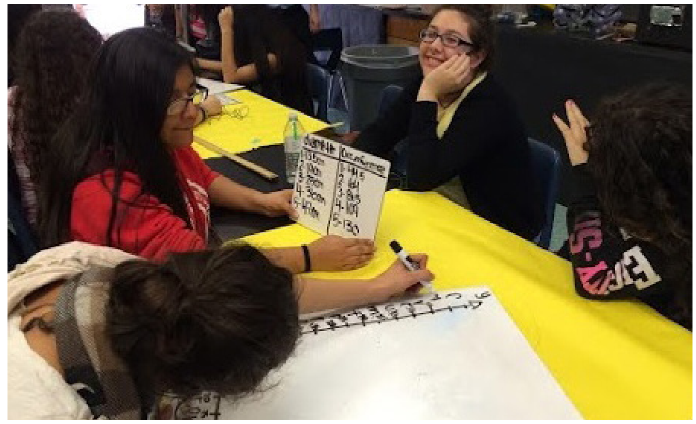


FIGURE 2. More ASAMI Students at Work

student learning. In the Modeling Instruction pedagogical approach, students work in groups of three. They voice their preconceptions, collect experimental data, build a model in their small groups, and document their ideas on whiteboards. Then the students assemble with their classmates for a "board meeting" to present their work and develop a class consensus model.

An example of how we implemented the model in ASAMI is shown in the diagram below.

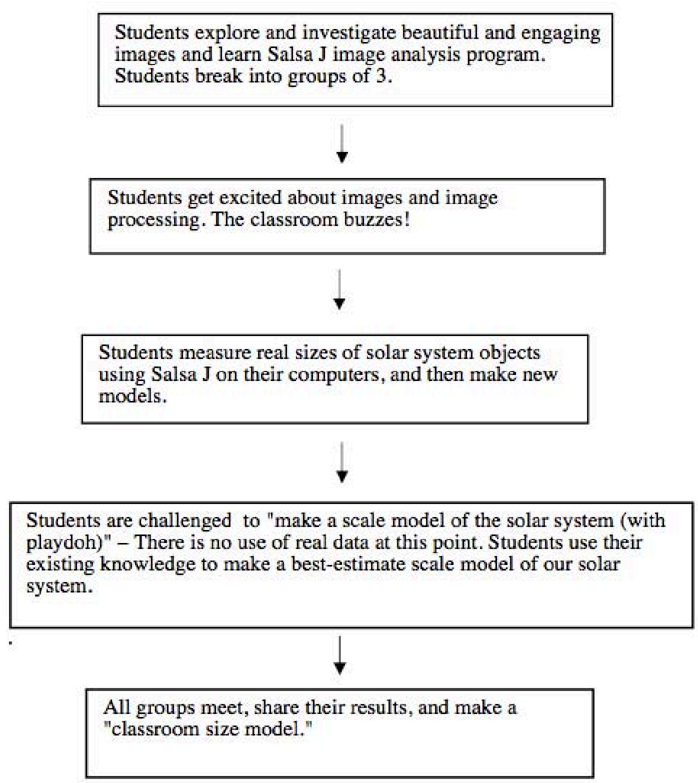
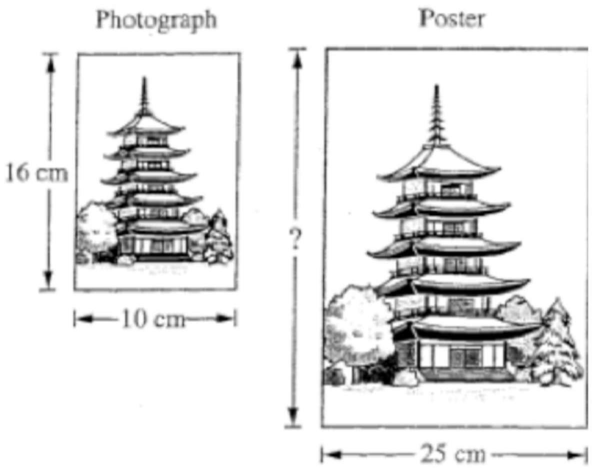


FIGURE 3. Typical Modeling Instruction Pedagogy in Action (2-hour Session)

DIAGRAM 1. Typical ASAMI Common Core Math Assessment Item



A photograph is enlarged to make a poster.
The photograph is 10 cm wide and 16 cm high.

The poster is 25 cm wide. **How high is the poster?**
Describe how you figure it out.

(The MAC Performance Assessment Task "Poster" is published with the permission of its authors, the Silicon Valley Mathematics Initiative.)

ASAMI Assessments of Common Core Math

The first goal of the evaluation was to assess the effects of students' participation in ASAMI on their understanding of proportional reasoning. To measure these outcomes, evaluators developed pre- and post-program content tests and surveys. Math assessments only were developed and implemented. The content tests contained five proportional reasoning items taken from four sources: (1) the California STAR test database; (2) the National Assessment of Educational Progress (NAEP) item database; (3) the New England Common Assessment Program; and (4) the Silicon Valley Mathematics Initiative's Mathematics Assessment Collaborative project.

An exemplary assessment item is shown in Diagram 1.

The lead teacher, who was also the main content developer, had not studied the assessments and was unaware of the detailed questions. Her focus was to develop and teach activities that were hands-on activities emphasizing Common Core math principles and tools.

Results of Assessments

Test Scores

We deployed our five assessment items in pre- and post-test sessions at the beginning and end of ASAMI. At Portola Middle School, only interviews were undertaken. All of the Common Core Math assessments were administered in the school years 2013–2014 and 2014–2015. While these assessments are viewed as a preliminary study, it is clear there was a gain in students' capabilities. Before starting ASAMI, students' skills were very low. Every group of ASAMI students had test scores that improved significantly beyond the control group's gains. In summary, students had about double the learning gain, compared to a preliminary control class. Hence, we view the ~2X more learning as a lower limit, compared to traditional learning.

The number of students assessed was typically about twenty per class, and the standard deviations were usually around one point. When we combine the data, the results become much more significant, with the summed results approaching significance at greater (1/sqrt(4)), at a 4 sigma significance. These results are very encouraging.

TABLE 2: ASAMI Pre- and Post-test Results

Date of ASAMI	Cohort	Pre-test Score	Post-test Score	Absolute Gain over Program	Length of Program	Normalized Gain/6 Weeks
Spring 2014	7th- 8th Grade Winton and Chavez	2.4	3.5	46%	6 weeks	46%
Fall-Winter 2014-2015	7th Grade Winton	1.7	3.3	93%	12 weeks	48%
Fall-Winter 2015 Control Group	7th Grade Winton Technology Elective	1.6	2.54	56%	12 weeks	28%
Spring 2015	8th Grade Winton	1.29	3.11	142%	8 weeks	106%
Spring 2015	7th Grade Bret Harte	1.15	1.85	60%	6 weeks	60%

It is interesting to note that the eighth-grade ASAMI students, who had undergone normal math education for most of a year, had pre-test scores similar to those of entering ASAMI seventh graders. These incoming eighth graders had learned little in the year and a half of math education since their entrance into middle school.

Student Interviews and Informal Observations

Interviews and observations were done at Portola Middle School, with parental consent and student assent forms per the UC Berkeley Committee for the Protection of Human Subjects Protocol # 2012-03-4125. These data suggest that students found the ASAMI activities to be highly engaging and quite different from typical classroom practices. Students worked diligently in groups on complex math and science problems, persisting on new and challenging tasks with the help of their ASAMI leaders. During one session, for instance, evaluators observed students using Salsa J software to calculate astronomical distances. A group of four students sat or stood in front of a computer, with one student running the program and the others providing guidance. The students were so engaged in the activity that they wanted only a brief snack break before returning to their work.

The root of ASAMI's appeal may be in its "useful application" approach to mathematics. Rather than teaching proportional reasoning as an abstract skill, ASAMI embeds it into science problems that pique students' interest. In fact, one student described the program as "an astronomy program which sneaks in math," noting that she often didn't "realize how much [math] you're doing" until later. It was only in the hours after ASAMI that she felt the full mental impact of what she had done: "My brain's tired. I've done too much math."

Another student also praised the ASAMI's activities, calling them "Math in a fun way. You don't know you're doing math but you are," she said. "I liked how they put the math. They didn't just give you like a paper with math problems and say do this. It was in a way where it was math but it wasn't just math, it was something else like astronomy." This same student commented that ASAMI was a very different from her regular math classes: "Most of the time now in school the teacher's on the whiteboard, we do problems, we do our homework and our work, but it's nothing like this, with measuring, with astronomy, with ratios, you know, it's not like how they put it." Before ASAMI, she didn't think that mathematics had much to do with science. "I didn't really think I needed science to do math. I just thought science was science and math was math and they were two different things." Now that she has been through the program, she wishes that all students could have the same experience. "By them [math and science] being joined together it makes it more interesting and more fun because you're not just doing math and you're not just doing science, but you're doing both of them at once."

General Observations and Success Factors

We believe there are several reasons why ASAMI has worked well.

- **Individual Tutoring**

We employed two or three Spanish-speaking high school and community college students in the ASAMI sessions. Hence, ASAMI participants received a lot of individual tutoring, and with the help of their own peer groups, were convinced to undertake rigorous work and struggle with Common Core topics.

- **Fun and Exciting Activities**

Math was always fun and often had instant consequences/feedback if you got things wrong. For example, in the playdoh recipe scaling activity, at least half of the students got the ratios wrong (many subtracted instead of using ratios) and they made playdoh with much too liquid a consistency. There was always fun and excitement in the hands-on activities, and we could keep them both involved and working rigorously, competing against other after-school activities. Students, when asked if this work was more fun and interesting than their normal math classes, would give staff a condescending look and say "Duh…"

- **Parent and Community Support**

We had great support from the parents. The leader of ASAMI community relations, Mr. Jesus Heredia, continually cultivated a strong relationship with the parents. The parents wanted ASAMI for their children, and if children did not attend the ASAMI sessions, the parents were informed, and usually the students came back. For these reasons, there was very low attrition in the student population (<12%). ASAMI was observed by staff to be desired by the parents as it promoted Common Core learning with an emphasis on technology, college, and jobs.

- **Strong Support from Our Hosting Schools**

Winton Middle School and Bret Harte Middle School provided superb hosting of our system. We had support from the administrators and from the after-school programs (Youth Enrichment Program), and custodial staff.

- **Strong Support from the School English Learner Advisory Committee (ELAC)**

We undertook very careful communications and briefing with the ELAC, especially at Winton Middle School; they were convinced of ASAMI's value, and they felt that ASAMI was their program.

- **Strong Support from the Hayward Unified School District (HUSD) Office and School Board**

ASAMI benefitted from great support from the HUSD central office. The whole development of our program, the funding systems, the invoicing and multiple layers of approval (including School Board approval) were all undertaken with vigor and enthusiasm by District staff.

- **Undying Dedication to Rigor and Common Core Math in Every Instance**

We did not have to dig deeply to find how proportions and ratios are used in our science problems, so we could both emphasize Common Core and complete these activities. For example, students learned in HOU that proportion and scale are used widely in the Universe and that, in fact, the Universe makes no sense without proportion and scale.

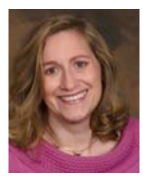
- **Buy-in from ASAMI Teachers**

One new instructor, Mr. Ben-Shalom, writes of ASAMI: "At first I was skeptical that struggling students would want to participate in yet more academics during their after-school time, and yet this program has amazed me. ASAMI will not work for everyone, but those students who it has reached have shown a kind of dedication and enthusiasm about math and science that I thought not possible. And this is due to ASAMI's solid repertoire of lessons and activities that are engaging and will help these students succeed."

Future Work

We are confident of our test score gains and students' indications of excitement about STEM topics. Future work (proposals are in the planning stages) will include a deeper study of these results and a more thorough explication of the success factors. As one local collaborator noted: "The ASAMI initiative has snowballed through the science department and inspired more student-centered and hands-on activities, generally." We will endeavor to spread ASAMI throughout the Hayward Unified School District and then beyond into other California schools, many of which are blessed with students and families eager to master the Common Core STEM topics and need some extra help from ASAMI as their language acquisition and skills develop.

About the Authors



Kristin M. Bass is a Senior Researcher at Rockman et al, a San Francisco-based external evaluation company. Kristin's areas of expertise include assessment development and validation, program fidelity, research design, and quantitative analysis. At Rockman, she primarily directs projects related to formal and informal STEM education. Kristin has a B.A. in psychology from Yale University and a Ph.D. in education and psychology from the University of Michigan.

Gabriel Ben-Shalom is a recently graduated teacher, who finished his student teaching with Ms. Lobo at Winton Middle School and became available to teach ASAMI for eighth-grade students. Gabriel benefitted in his own education from hands-on and conceptually deep activities, and he was eager to be involved in ASAMI, particularly as he witnessed U.S. Science and Math education move into an era of Common Core and NGSS. He was very delighted when he found the students tackling hard problems and making progress in their own learning. In fact, as we note in the paper, the eighth-grade students in Gabriel's class had very large gains on the math Common Core assessment items, which is a tribute to his teaching skills.

Jesus Heredia is an English Language Learner (ELL) Specialist at Winton Middle School in Hayward, CA. He was formerly a teacher, but moved into ELL work when he saw the tremendous potential of these students, coupled with their strong need for activities that engaged and supported their core learning. Hence, ASAMI spoke naturally to his sense of what the students needed. Jesus was diligent in working with the families of the students, and through his efforts, we saw very low attrition in the ASAMI classes. Jesus helped convince the English Language Advisory Committee that ASAMI was in their children's best interest. Jesus also played an essential role in the total running and management of ASAMI and was in the ASAMI classroom almost continuously.

Rainbow Lobo is a teacher in the Science Department at Winton Middle School in the Hayward Unified School District. She teaches science and technology and has been an advocate of hands-on, student-centered learning for most of her career. Students in her technology elective class demonstrated large gains in their grades after a year of Lobo's class. She provided ASAMI's home (her classroom), ideas on classroom management, and continuous input and ideas in this study.

Carl Pennypacker is a physicist and educator who has been fortunate to play pivotal roles in some decent projects. He received his B.A. from UC Berkeley in 1972, with the group of Luis Alvarez. Together with Richard Muller, Pennypacker has helped form and develop many of the central ideas that have led to the discovery of Dark Energy. He and his team were winners of the Gruber Prize and the Breakthrough Prize for this work, and the student he co-advised, Saul Perlmutter, went on to accrete the Nobel Prize for this work. Pennypacker helped co-found, with a group of great teachers and educators, the Hands-On Universe project. This project has led to the training of 1000 teachers in the United States, and about 20,000 around the world, and is part of the French National Curriculum and the Bavarian State curriculum.

Jennifer Perazzo is a Hands-On Universe Teacher Lead. She is also a certified Modeling Instruction teacher. During the school year she is a Science Specialist for an elementary school in Pleasanton, CA. She introduces students and teachers to the EU-HOU astronomical image analysis tool, Salsa J, a software program dedicated to image handling and analysis in the classroom. Jenifer created and taught most of the ASAMI activities for the seventh-grade class.

David R. Stronck is a Professor in the Department of Teacher Education, California State University, East Bay. Oregon State University awarded him an M.S. in Biological Sciences and a Ph.D. in Science Education. He is the sole author of 22 articles reporting statistical research in major journals of learned societies. He has a total of more than 200 publications, including eight books. For ten years, he was the editor of journals for science teachers. Stronck has been the director of projects that have been funded at more than $3 million. He has directed or co-directed 15 grants for the National Science Foundation. The Genentech Foundation for Biomedical Sciences funded his projects serving high-school students, for more than one million dollars. He has also directed four grants from the U.S. Dept. of Education. He presents at an average of five different conferences annually, e.g., the National Science Teachers Association.

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Appendix 1: Alan Friedman and HOU

Alan Friedman established and directed the Lawrence Hall of Science Planetarium (University of California, Berkeley) in 1973. For over a decade his leadership set the legacy of audience participation planetarium shows and hands-on science at Lawrence Hall. He was a pioneer in the field and involved hundreds of planetariums through Participatory Oriented Planetarium (POP) workshops and the publishing of the Planetarium Educator's Workshop Guide, which evolved into Planetarium Activities for Successful Shows (PASS; now at http://www.planetarium-activities.org/). To this day LHS helps bring that style of show into the digital age and encourages other digital planetariums to include live audience participation in their repertoire of shows, rather than just recorded programs. Among the planetarium shows Alan developed were Stonehenge and Finding Your Star (now Constellations Tonight), in which the presenter hands out star maps to all the audience members and teaches them how to use them. Using star maps was to become a favorite tool of HOU observers in the guise of Uncle Al's Hands-On Universe Starwheels. Cary Sneider became Planetarium Director after Alan Friedman, and it was under Cary that the first connection with HOU was made in 1991. Cary had been invited to the seminal HOU organizing workshop but was unable to attend and asked Assistant Director Alan Gould to go in his stead. At the workshop, Alan presented an activity from one of the planetarium shows, Moons of the Solar System, in which the audience members kept track of the moons of Jupiter and discovered the relationship between the moons' orbital periods and their orbital radii. That ultimately evolved into one of the favorite activities in the HOU high school curriculum. Years later, Alan Gould became Co-Director of HOU for a number of projects.

Appendix 2: Typical ASAMI Activities

ASAMI Activity	What Students Do	Math Common Core Concept
Derive a correct recipe and then make playdoh	Students scale from a recipe that requires too much of one ingredient	Ratios and proportion
Make a scale map of their school, from Google Maps	Use Google Maps and HOU image processing to measure true diameters of objects and measure their school, culminating in a scale map of some buildings, etc.	Ratios, proportion, scale, measurement
Make a scale solar system	Students take an existing playdoh recipe and scale it for the smaller amount of materials they are given	Ratios and proportion
Lunar Craters - find a lunar crater as big as your county from computer images	Students find a crater as big as their county, plot a map of the State of California on a moon map, use different map scales and compare maps.	Proportion and ratios
Asteroid Impact - drop various size stainless steel balls into birdseed on a tray	Students drop various mass spherical objects into bird seed (works better than flour) from various heights, and plot crater size versus height, mass, etc.	Energy, proportion, mass, etc.
Water Rockets	Build and launch, then measure and graph results from experiments with water rockets	Proportion

Final Note

Science Education and Civic Engagement: An International Journal is a peer-reviewed, twice-yearly periodical published by the National Center for Science and Civic Engagement (NCSCE). Established in 2004 at the Harrisburg University of Science and Technology, NCSCE's mission is to inspire, support, and disseminate campus-based science education reform strategies that strengthen learning and build civic accountability. As of 2015, NCSCE's new institutional home is Stony Brook University, where it continues to serve as a national resource for improving education and strengthening our democracy.

The signature program of the NCSCE is the National Science Foundation (NSF) funded Science Education for *New Civic Engagements and Responsibilities (SENCER)*. SENCER courses and programs improve learning by supporting faculty in teaching "to" basic, canonical science and mathematics "through" complex, capacious, unsolved problems of civic consequence. Using materials, resources, and research developed through the SENCER program, faculty design innovative curricular projects that connect science learning to real world challenges of immediate interest to their students.

Since 2001, with the support of the National Science Foundation, the W.M. Keck Foundation, the Noyce Foundation, the US Environmental Protection Agency, the Corporation for National and Community Service, and our institutional partners, SENCER has established and supported an ever-growing community of faculty, students, academic leaders, and others committed to improving undergraduate STEM (science, technology, engineering, and mathematics) education.

SENCER's origins can be traced to the 1980's to a course that used the HIV epidemic to teach biological concepts. This approach not only increased student interest in biology by linking it to a very pressing health crisis, it increased student learning as well. The course, *Biomedical Issues of HIV/AIDS*, formed the foundation of the SENCER Model series, which now includes over 50 exemplary courses and programs from a wide range of institutional types and STEM disciplines, including physics, geology, biology, chemistry and public health, environmental sciences, and conservation sciences.

From these beginnings, the NCSCE has increased the scope and scale of its networks and partnerships. In addition to a national office in Washington, D.C., there are nine regional SENCER "Centers of Innovation" that include Butler University, Case Western Reserve University, George Mason University, Roosevelt University, Rutgers University, Santa Clara University. Texas Woman's University, University of North Carolina-Asheville, and Worcester Polytechnic Institute,

Since 2012, two new projects, also funded by NSF, have encouraged the adoption of SENCER strategies in new contexts. *Engaging Mathematics* has established a partnership among six colleges and universities committed to applying the SENCER approach to both new and existing courses that use civic issues to make math more relevant to students. *SENCER-Informal Science Education (SENCER-ISE)* aims to improve STEM learning in classroom and the wider community by supporting collaborations between informal science and higher education institutions. SENCER-ISE currently includes nine cross-sector partnerships offering a range of civic engagement activities for K-12, undergraduate and graduate students, and the public.

SENCER-ISE was conceptualized and initiated by the late Alan J. Friedman, who served as its founding director until his death on May 4, 2014. With Alan's guidance and inspiration, SENCER-ISE has emerged as a groundbreaking and influential pilot initiative. We hope this tribute issue of *Science Education and Civic Engagement: An International Journal* conveys, in some small measure, his lasting legacy and impact on science education and the museum community.

For more information about NCSCE and its individual initiatives, please go to www.ncsce.net or call 202 483-4600.

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