REVIEW

Building a Model for Collaboration between Higher Education and Informal Science Educators:

A Case History of SENCER-ISE and the Application of a Civic Engagement Cross-sector Framework in STEM Learning

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Abstract

This article provides a case history of the beginnings of SENCER-ISE (Science Education for New Civic Engagements and Responsibilities – Informal Science Education), an initiative that encouraged structured partnerships between higher education and informal science educators using civic engagement as a unifying framework for the collaborations. The article provides background on why SENCER-ISE was a natural progression for the National Center for Science and Civic Engagement (NCSCE) to pursue and how SENCER-ISE was implemented. Partnership projects and specific outcomes are provided as examples of the civic engagement cross-sector work and evaluation results are given of the overall efficacy of such partnerships.

Introduction

- *Formal partnerships*
- *Long-term relationships*
- *Audiences served by informal and formal educators expanded*
- *Civic engagement focus as a strategy for learning*
- *Partners' areas of expertise respected*

These are some of the positive outcomes expressed by educators who participated in SENCER-ISE (Science Education for New Civic Engagements and Responsibilities-Informal Science Education), the National Center for Science and Civic Engagement's (NCSCE) cross-sector pilot project to bring together individuals from the higher education (HE) and the informal science education (ISE) sectors through civic engagement partnerships (Randi Korn & Associates [RK&A], September 2015). The initiative was a natural outgrowth of NCSCE's fundamental emphasis on framing teaching and learning around real-world problems and experiences. Civic issues, whether related to water quality, invasive species and habitat loss, or education, formed the underpinnings of the projects developed through SENCER-ISE, an initiative that benefited from the infrastructure provided by NCSCE.

As one informal science education partner noted in an evaluation report from Randi Korn & Associates (RK&A, September 2015),

> From just looking at the other projects and learning about the other projects in my cohort, it seems like [our] project was true to what SENCER's philosophy is, the way SENCER first started. We're not going to keep science in a bubble or a laboratory, but we're going to actually apply it. … We went to the workshop before the project really kicked off to learn more about the philosophy,… and how it's been used to add another dimension to college courses, that was cool, and that's what made this class so successful, that idea, that philosophy.

This case study will examine the experience of implementing the first stages of SENCER-ISE and will review the initial results. The study will outline the partnership projects to provide the context of how building an initiative around a civic issue can focus implementation efforts, meet actual challenges, and provide benefits to the educators and to the audiences served.

Background: Developing a Concept

In October of 2008, the National Center for Science and Civic Engagement (NCSCE) began a journey that continues as of this writing. Interest in exploring the practicality of civic engagement cross-sector partnerships heightened for NCSCE leadership, a number of informal science educators, and external funders, and they could see potential benefits to justify investing in infrastructure support to strengthen nascent or more casual collaborations. The setting was a MidAtlantic SENCER Center for Innovation regional meeting held at Franklin & Marshall College (NCSCE, MidAtlantic (dated incorrectly October 4, 2009; it was actually October 4, 2008) The meeting focused on the critical role of K-8 STEM (science, technology, engineering, and mathematics) education as a "gateway" to STEM achievement.

One of the speakers, the late Alan Friedman, presented on a variety of topics that day, including a breakout session on communicating science to the public. Friedman had been the longtime director of the New York Hall of Science. At the time of the Franklin & Marshall meeting, Friedman was a consultant in museum development and education. He became the founding director of SENCER-ISE.

Through discussions at the meeting about the work of SENCER in engaging students with real-world civic issues, Friedman began to form a kernel of an idea that became the SENCER-ISE initiative. In an email to then NCSCE Executive Director David Burns and others on November 9, 2008, Friedman noted that "informal science education is open to the lessons of SENCER," in that citizen science and science centers were paying "increasing attention to social issues." He thought that a "working" conference to investigate the point of view of each sector towards civic engagement and to develop effective strategies to make collaborations work would be a next step. Others at the time wrote about the importance of seeing the formal and informal sectors as a continuum for learning through formal classroom use of "free-choice science learning resources and opportunities … for field trips or

… guest speakers" (Liu, 2009). Friedman had something more in mind, in that he saw how SENCER's model of learning through the lens of civic issues could impact the outcomes of potential partnership projects.

The following October, another MidAtlantic Center meeting at Franklin & Marshall focused on how informal science education experiences could improve college readiness. Friedman was one of the key speakers, along with David A. Ucko. Ucko was then Deputy Division Director, Research on Learning in Formal and Informal Settings, at the National Science Foundation; he, along with Marsha Semmel, are both independent consultants and became senior advisors for informal science education at NCSCE after Friedman's untimely death. Both Friedman's and Ucko's presentations focused on the world of informal science education and its relationship to K-12 and higher education.

Over the next two years, other discussions, presentations, and proposals culminated in SENCER-ISE, an invitational conference held in March of 2011 (funded by the NSF, DRL1001795, and the Noyce Foundation) that brought together 20 SENCER faculty members and other NCSCE staff, with 20 professionals from informal science education institutions, such as science and nature centers, museums, and science media (NCSCE, 2011). As a result of this meeting, the "cross-sector partnership" concept developed into the SENCER-ISE II initiative (aka SENCER-ISE). Six partnerships were funded by the National Science Foundation (DRL1237463) and four by the Noyce Foundation. Eight of these ten partnerships continued with some type of collaboration at least through the end of the funding period.

The purpose of SENCER-ISE, to paraphrase what Ucko noted during a presentation at the 2017 SENCER Summer Institute, was to show that through the framework of civic issues, we could find common ground and "leverage synergies" for cross-sector partnerships that could "foster STEM learning and public engagement" (Concurrent Session on SENCER and Informal Science Education, Summary Slide found at ncsce.net/concurrent-session-sencer-and-informal-science-education-ssi-2017/). Ucko had previously written about SENCER synergies with informal science education in the Summer 2015 issue of this journal, which served as a tribute to Alan Friedman and focused on informal science education connections to formal education.

Background: NCSCE's Path to Cross-sector Civic Engagement Partnerships

Although there are many differences between formal and informal science education learning environments, there are commonalities between SENCER Ideals, its approach to learning (http://sencer.net/sencer-ideals/), and the informal science education community's goals. For NCSCE staff and colleagues, the timely publication of the 2009 NRC report, *Learning Science in Informal Environments: People, Places, and Pursuits*, fueled the notion that the underlying possibilities of higher education faculty and informal science educators working together collaboratively could evolve into enduring civic engagement partnerships. The NRC report postulated "strands of learning," which in many ways reflected such SENCER Ideals as starting the learning process with matters of interest to students, beginning with projects that are practical and engaging to students, and locating the responsibilities of discovery in the work of the student (Friedman & Mappen, 2011, p. 32).

The March 2011 invitational conference, with its goals of sharing the strategies higher education and informal science education (HE-ISE) communities used to "implement the civic engagement approach" and "mapping possible collaborations," found a mutual interest by professionals from both sectors in developing "science-enabled citizens" and in using civic engagement platforms as a bridge across the sectors. Another important focus of discussion at the conference was the importance of "a continuum of engagement to address learner interests and needs from K-12 through higher education and adult learning, including both in-school and out-of-school learning opportunities" (McEver, Executive Summary, 2011). The conference evaluator's report concluded that "there was a need to build awareness of the value of using civic engagement as a platform to advance science understanding, including what each sector brings to a potential collaboration…" and that "the SENCER-ISE conference successfully sparked ideas and built momentum for collaboration" (RK&A, 2011). The evaluators noted that

sustaining the momentum after the conference was a challenge given daily responsibilities, not an uncommon factor in developing and maintaining meaningful partnerships. Two articles by Friedman and Mappen detailed the path to SENCER-ISE through 2012.

The first, published in this journal in 2011, focused both on the idea of differences and commonalities in learning environments and goals between these educational sectors and also on the 2011 conference. The second one, a chapter published in 2012 as part of an edited volume on the expanded use in science education of the SENCER model of learning through the framework of civic issues, looked more deeply into the idea of developing an infrastructure to support partnerships between informal and formal higher educators and the potential benefits and challenges of collaboration "across the HE-ISE divide."

The 2012 chapter also noted that most interactions between formal and informal education occurred at the K-12 level. The value of this connection between the two sectors can be seen in some earlier works, which also speak to the need to make these relationships more meaningful. An article summarizing two research studies about Informal Science Institutions (ISIs) published in the *International Journal of Science Education* in 2007 highlighted that these institutions "support K-12 education in the United States in important and varied ways" through field trips and other outreach programs but concluded ISIs had at that time "yet to determine how best to support students and teachers in terms of the actual curriculum and materials used in the classroom," which could have "rich potential" for school science education (Phillips, Finkelstein, & Wever-Frerichs, 2007). To paraphrase Bevan and Dillon (2010), the "ubiquitous use of field trips" hid the gulf between creating substantial partnerships for learning in formal and informal contexts and one-shot experiences (pp. 176–177). Rivera Maulucci and Brotman (2010) summarized an in-service and preservice teacher training seminar that utilized trips to a museum "as a place to learn science connected to mandated science curricula" in NYC that began to "bridge" the gap between formal and informal science learning by including a local natural history museum, local public schools, and an undergraduate teacher education program as the partners.

From 2008, Friedman's developing vision for collaboration between higher education and informal science institutions was based on his analysis that the SENCER approach to learning, which engaged "students with real civic and social issues," could shape students' understanding of "how important science, technology, engineering and math [was] to their own lives and to their communities." At the same time, he thought that the informal science education community that he knew so well was "discovering the importance of this strategy" (Friedman, email, November 9, 2008).

That Friedman could imagine the future direction the informal science education community would take is evidenced by a May 2016 report by the Center for Advancement of Informal Science Education (CAISE, May 23, 2016) that highlighted the expanding landscape of informal science education over the previous ten years. SENCER-ISE was certainly part of this development, with its emphasis on collaborative work across the sectors and the involvement in most of its projects of students at different educational levels communicating science to targeted audiences in schools, science centers, and citizen science organizations. As noted, Friedman saw early on the possibilities of these types of collaborations. One conclusion of the CAISE report for the ISE community is the need to "build greater awareness of the values and goals of universities and academia, e.g., graduate student professional development and undergraduate enrichment experiences" (p. 15). Friedman foresaw this possibility a decade ago, and he also saw how much the higher education community could learn from informal science educators, especially in terms of communicating science to a diverse audience.

Background: From Vision to Implementation

While the major goals of the second phase of SENCER-ISE were to form enduring partnerships around compelling civic issues that could "provide models for others in the wider educational community to follow," there was an interest in "building the knowledge base" to improve "the fields' understanding of the nature (challenges and high potential) of HE-ISE partnerships" (email from Wm. David Burns to Alphonse DeSena and Myles G.

Boylan, June 6, 2012). NCSCE would provide the infrastructure support to launch new or enhanced partnerships. SENCER Ideals and informal science education's learning strands offered the intellectual framework for this "experiment."

From the 2011 conference on, there were certain elements that those involved in creating and implementing the next phase of SENCER-ISE thought necessary for it to succeed. Appendix A lists key themes of discussions that began with the March 2011 conference and continued through a November 2011 follow-up meeting, the December 2012 Leadership Team meeting held after the NSF funding was received (the team included Burns, Friedman, NCSCE staff, representatives from RK&A, Advisory Board members, and others), and into the partnership recruitment and selection process. While not all of the strategies that emerged from these discussions were incorporated into SENCER-ISE, they do provide suggestions for an implementation framework from which to develop and sustain collaborative efforts for those interested in creating or enhancing cross-sector partnerships. The themes include

- sharing information, both in person and remotely, including program outcomes;
- creating joint experiential opportunities and new learning and work environments around civic engagement that contributes to problem-solving of compelling issues;
- securing funding for test beds;
- mentoring for project leaders/partners;
- demonstrating respect for all partners and their different organizations;
- providing institutional leadership support for partnership; and
- meeting the challenges of working across sectors.

As a result of outreach to formal and informal science education communities, NCSCE received 30 applications for the initial six partnerships of $50,000 funded by the NSF, payable over a three-year period. Each of the applications was reviewed by at least five members of the Leadership Team and then discussed on a review call in April. When funding from the Noyce Foundation was awarded in July to support four additional partnerships, a decision was made to review again the top-ranked applications that were not selected in the first round.

Table 1 provides an overview of the ten partnerships and the civic issues that were proposed. The reviewers thought that these projects had the potential for

TABLE 1: SENCER-ISE PARTNERSHIPS – OVERVIEW OF ORIGINAL PARTNERSHIP PROJECTS

Partnership	Proposed Project Titles/Brief Descriptions
Antioch College/Glen Helen Outdoor Education Center	**Design** curriculum for an introductory Environmental Sciences course around the issue of biodiversity loss
Brooklyn College/Gateway National Recreation Area of the National Park Service	**Develop** collaborative learning communities around monitoring the resilience of Jamaica Bay, an urban estuary
Cornell University/Sciencenter	**Create** tools for parents/caregivers to learn the science of cognitive development
Fordham University/Wildlife Conservation Society	**Engage** high school students in a research program in urban ecology
Hamilton College/Green Science Policy Institute	**Develop** research opportunities for undergraduate science students
New Mexico EPSCoR/New Mexico Museum of Natural History	**Bring** together a network of informal science education institutions with a network of university-based researchers in issues related to water and energy
Paul Smith's College/The Wild Center	**Engage** college students in climate science communication with community gatekeepers
Raritan Valley Community College/New Jersey Audubon	**Involve** community college students and citizen scientists in the assessment of forest health in central New Jersey
Saint Mary's College of California/Lindsay Wildlife Museum	**Explore** the issue of urban habitats in the San Francisco Bay area
University of Connecticut/Connecticut Science Center	**Create** a "genome Ambassadors" program for family audiences

longer-term relationships. Appendix B provides project titles and more detailed descriptions about the projects. See also http://sencer-ise.net/partnerships/ for more background information about the original partners, institutions, and activities.

Getting Started – Introducing Partners to NCSCE, SENCER, and SENCER-ISE

SENCER-ISE objectives included building connections and relationships between partners, across partnerships, with the SENCER-ISE staff, and with the larger NCSCE community while applying SENCER's civic engagement framework. An orientation to SENCER-ISE and participation in a SENCER Summer Institute were two activities planned as part of the implementation process. Given the differences in the award timeframes, the NSF-funded partners attended the institute in the summer of 2013, where they participated in a pre-institute orientation session; the Noyce partners participated in an orientation program in October of 2013 and then attended the institute in 2014, where they also interacted with the NSF-funded partners.

Both orientation sessions provided guidance on the planning process, discussions about known obstacles to cross-sector collaborations, ideas about developing strategies to overcome challenges, and workshops on evaluation planning (clarifying project outcomes, developing indicators, and choosing data collection methods). To continue communications beyond the orientation gatherings, group video conference calls, individual partnership calls with SENCER-ISE staff, and a website for shared information were offered.

Planning and Implementing Cross-sector Partnerships: Challenges

Amey, Eddy, and Ozaki's "Demands for Partnership Collaboration in Higher Education: A Model," published in 2007 in *New Directions for Community Colleges (NDCC)*, noted that "partnerships in academe are becoming more common" but that "relatively little is known about them." Thus, these types of collaborations are "often challenging to develop and hard to sustain." The authors raise questions about each participant's motivation for engaging in collaborative efforts, differences in the organizational context of the partners, the departure of "critical" personnel, and differences in desired outcomes (pp. 5, 12–13). The focus of the chapter was on K-12 schools and colleges, but the content is highly relevant to the work between informal science education institutions and colleges and universities.

The Executive Summary for the March 2011 conference report, the project proposal, and subsequent experience with implementing SENCER-ISE echo some of the themes and questions raised in the NDCC chapter. Conference participants identified "potential obstacles," that ranged from mutual misunderstanding about the work of the other sector, conflicting cultures and reward systems, different work patterns and crunch times during the year, and different views of the role of civic engagement. Higher education "participants saw civic engagement with science and technology-based issues as a means towards the end of science learning, while most of the ISE participants saw civic engagement with such issues as a valuable end in itself."

NCSCE's grant proposal to the NSF (2012) highlighted some of the *key challenge*s Friedman and others saw in forming non-profit partnerships, especially between higher education and informal science education institutions. These challenges, along with some potential proposed solutions to how they might be overcome, included the following:

- *Difficulties in establishing and sustaining non-profit partnerships*. Initial responsibilities, decision-making prerogatives and commitments from both sides need to be clearly defined from the start, although some flexibility is needed.
- *Differences in culture*. These are rarely accounted for initially and can lead to misunderstandings as the partnership develops. Both sides need to begin to understand the different constraints and values.
- *Friction caused by time and other resource commitments*. These should be defined and agreed to in writing at the beginning.
- *Institutional vs. individual commitments*. These are often not appreciated at the beginning of a partnership.

- *Ad hoc relationships rarely are sustained*. Organic relationships with goals that meet the mission needs of both partners are more likely to succeed.

In designing the plan for SENCER-ISE, the above broad challenges were taken into account. It was thought that they could be mitigated by

- setting up a small central office to support the partners;
- having partner institutional representatives sign a Memorandum of Understanding about requirements for receiving funds;
- providing opportunities for communication between the partnerships through a website that contained information about the partnerships and milestones for activities (timelines) and also through scheduled video conference or telephone calls;
- offering evaluation guidelines and training at the beginning of the partnership implementation period;
- awarding start-up funds; and
- attempting to integrate the partners into the larger NCSCE orbit.

As the partnerships got underway and as they progressed, other challenges cropped up, some more difficult than others to solve, some unique to individual institutions, and some related to reporting requirements and schedules proposed by SENCER-ISE staff.

The partners spoke about some of their challenges in their final reports. For example, faculty sabbaticals and staff changes occurred in over half of the partnerships. In one case, the partners maintained telephone contact, while the faculty partner's students continued at the ISE facility. There was some scaling back of the project and the ISE educator took on more of a supervisory role. In the other sabbatical case, the program was refocused a bit. In both of these cases, flexibility was important. For the most part, staff changes were overcome, except in two of the partnerships. Both of these involved a faculty member and/or a staff person changing institutions. For one partnership, the changes occurred several times and the final change did the project in. For the other, the missions of each partner were too disparate. Still other challenges, more related to specific institutions, included Institutional Review Board issues, travel for participants, securing additional funds, teacher attrition, attracting sufficient audiences, and for some a concern over the quality of student-collected data. Fortunately, the two partnerships that relied on student data collection reported that the data collected were authentic and of good quality.

Evaluating SENCER-ISE

To evaluate the SENCER-ISE infrastructure and follow partnership progress, both external and internal evaluation methods were employed. RK&A was engaged to undertake both formative and summative evaluations. Annual reports and quarterly group video or individualized calls with each partnership provided updates about partnership activities. Each partnership also evaluated the impacts of their efforts on populations they served (students, teachers, communities), and these results were reported in final partnership reports.

Formative Evaluation

The formative evaluation examined partner perceptions of the SENCER-ISE infrastructure. RK&A conducted in-depth telephone interviews of 20 participants, representing all ten partnerships, between June and September 2014. About one-half of the interviewees were from higher education and the other half from informal science education. The interviews produced descriptive data that were analyzed qualitatively, "meaning that the evaluator studied the data for meaningful patterns and, as patterns and trends emerged, grouped similar responses" (RK&A, April 2015).

Five trends emerged when the strengths of the SENCER-ISE infrastructure were examined: (a) **funds,** which helped secure personnel for the project; (b) **structure,** which for some helped the partners focus on quarterly progress; (c) **inspiration**, which for some helped to establish a connection with colleagues; (d) **encouragement and feedback**, which for some provided moral support; and (e) **flexibility**, which for some meant that the reporting process was adjusted based upon partner feedback. There were no discernable differences in responses by sector.

There were four major challenges: (a) **partner relationship**, which included for some communication issues and differences in schedules; (b) **lack of clear**

expectations, which for some meant not knowing how much reporting was necessary, even with the Memorandum of Understanding listing reporting dates; (c) **limited funds plus workload,** which some thought should be adjusted so that some of the administrative work could be lessened; and (d) internal issues, which for some included personnel leaving the institution or a partner being on academic leave. There were few differences by sector.

Summative Report

For the summative evaluation, RK&A employed a "mixed-methods approach to explore the …[evaluation] objectives—in-depth interviews and standardized questionnaires." Eighteen interviews were conducted with SENCER-ISE partners. As with the formative interviews, these interviews produced descriptive data (RK&A, July 2015). The summative evaluation explored *four evaluation objectives*. The first three focused on whether the partners

- increased their understanding of each other's field of expertise;
- appreciated the value of each other's work and expertise; and
- increased their understanding of what creates a durable partnership.

The fourth objective explored whether colleagues of the partners realized "the value of the formal/informal education collaboration."

The evaluators noted that "while these are the evaluation objectives, one can easily see what the project aspired to achieve in how the objectives are expressed. As such, the evaluation objectives can also serve as a list of the project's outcomes" (RK&A, September 2015).

The responses are summarized in Appendix C, which provides statements made by the interviewees. Overall, the partners did increase their understanding of each other's work and expertise, did appreciate the value of each other's work and expertise, and did understand elements of durable partnerships. Some interviewees noted that others at their institutions were drawn to the efforts.

Partnership Results, Impacts, and Sustainability

The work of the partners on their individual initiatives was really the backbone and strength of SENCER-ISE. It is through the lens and words of the partners that we can see the benefits of cross-sector collaborations to learners (students, citizen scientists, community members) and to faculty members and informal science educators. The sections below contain excerpts from the final reporting of eight of the partnerships (October 2016) that were still in existence, starting with some of the reported results.

The partnership reports also provide insight on how cross-sector partnerships can impact science education and educators, including pedagogical methods of the partners and their colleagues and how the involvement of students from different levels of education (graduate, undergraduate, K-12) was a benefit to the work of both sectors.

In terms of the sustainability of cross-sector partnerships the eight were still hoping to keep the partnership relationships going in a variety of ways, even if different from their original projects.

Reported Results

Brooklyn College and the Gateway National Recreation Area of the National Park Service

Awareness of the marine plastic debris issue is growing in the school community. Schools/teachers are engaged in data-driven civic engagement. The marine plastic debris protocols developed through the project are used in undergraduate classes.

Cornell University and the Sciencenter

Sciencenter staff trained students from the Cornell lab on methods in informal science education. Students then came to [the Sciencenter] Head Start family engagement events, and helped facilitate activities with parents and their children. …The students contributed to family engagement events by providing examples of current research about how children learn and how that research can be applied to the activities [the Sciencenter] offered to the parents and their children.

Fordham University and the Wildlife Conservation Society

The content evaluation indicated participation in Project TRUE [Teens Researching Urban Ecology] caused a significant increase in students' understanding of the scientific process and scientific bias. …After participation in Project TRUE, there was a 51.36% increase in

students' understanding of the scientific process, and a 76% increase in students' ability to recognize types of bias sampling.

New Mexico EPSCoR and the New Mexico Museum of Natural History

Hosted three successful retreats with keynote speakers (John Falk, Jamie Bell, and Rick Bonney). Provided funding for regional gatherings through a mini-grant program.

Paul Smith's College and The Wild Center

As part of the "Communicating Climate Change" course offered in 2014 and 2015, students were given the opportunity to receive certification as Interpretive Guides through the National Association for Interpretation. … In 2014, eight of the 15 students …participated. In 2015, all 15 of the students received certification.

Raritan Valley Community College and the New Jersey Audubon

Recruited and trained fifty-five … volunteer citizen scientists . … [and] involved … eighty students through participation in course work and volunteer training [over the course of the project]. …Students [for example] led a training session for …citizen scientists in invasive plant identification and gave presentations to local stakeholders.

St. Mary's College of California and the Lindsay Wildlife Experience

A smartphone app creation was both an instructional experience and it yielded LWE [Lindsay Wildlife Experience] a tool to educate the general public on how to interact with wildlife. …

The University of Connecticut and the Connecticut Science Center

During the course of the project two genomics program/exhibit formats targeted at family audiences were designed and tested. One component focused on "Mutations-DNA Matching Pairs" and the other on "STEM Cells." … Based on a random sample of visitors informally surveyed, …visitor's post engagement demonstrated a 67% increase in the ability to answer a series of six questions about mutations correctly, and a 75% increase in the ability to select the correct response from a series of four questions about STEM cells.

Reported Impacts

Brooklyn College/Gateway National Recreation Area of the National Park Service

The project helped to extend notions of place-based environmental education, in particular the ways to connect students who live in urban areas to the environment and related issues through authentic science learning activities. It also provided an example of how schools and teachers could contribute to and use scientific data in the classroom.

Cornell University/Science Center

The ongoing impact will be in the pedagogical methods of the Sciencenter. … Research from the [Cornell] lab … [led to a] new practice of open exploration and sharing research-based content with guests.

Fordham University/Wildlife Conservation Society

One of the major contributions that Project TRUE can have in the field of science education is that a program for students from under-represented populations in STEM fields [using] urban ecology research (i.e., place-based field research) with near peer mentors, as well as mentors from both informal and formal learning environments, can be effective in increasing knowledge [and] increasing student engagement in a sustained topic. …

New Mexico EPSCoR/New Mexico Museum of Natural History

One of the major outcomes of this project was uniting the informal science educators within NM ISE Net. … Keynote speakers provided opportunities for learning and … starting points for dialogue. …The educators were connected to local NM EPSCoR researchers with the broad goal of improving engagement with the public around energy research.

Paul Smith's College/The Wild Center

Many of the gatekeeper audiences … were empowered by the student presentations in measurable ways, helping them better engage their broader communities about mitigating the regional impacts of climate change and making more environmentally informed decisions. …The students themselves also represent an important gatekeeper audience. … Environmental science, natural resource, forestry, and outdoor recreation students preparing to

enter the workforce are uniquely positioned to be useful interpreters of this information.

Raritan Valley Community College/New Jersey Audubon

The project has demonstrated the success that is possible when sufficient resources (time, energy, money, and expertise, etc.) are devoted towards reaching the goals of conducting research and fostering civic engagement in first- and second-year science students. …These kinds of investments from both parties…are not always available, so it helped [the faculty member] refine and streamline his teaching methods to focus on the essential skills and lessons needed to make student participation in this kind of integrated education-research-engagement project a success. … NJA [New Jersey Audubon] staff have grown to appreciate the value of this type of partnership and working with students and faculty to address conservation issues. …The SENCER model [is] likely to be used in future projects.

St. Mary's College of California/Lindsay Wildlife Experience

Before SENCER-ISE, LWE did not look beyond its own inside sources for research or sharing. By utilizing student interests in environmental topics, the topics of interpretation to the public have opened up to include an emphasis on the bigger picture of major themes such as conservation, environmental impact, and loss of ecological habitats.

University of Connecticut/Connecticut Science Center

Two areas of the project that are likely to have significant interest among science educators and exhibit developers are the process of engaging high school students in the design and development of science education programs and exhibits, especially in collaborative teams with formal and informal educators and content experts from the research community (typically through universities and colleges). … and the use of improvisational training for team building and enhancing the communication skills of program staff and high school students. …The project [also] reframed the methods used by the Co-PI in both classroom and non-classroom settings for genomics discourse.

Sustainability

Brooklyn College/The Gateway National Recreation Area of the National Park Service

[Brooklyn College plans] to continue to collaborate with the NPS [National Park Service] on the marine debris plastic and other science and science education initiatives. The plastics protocol and associated activities will continue to be implemented in the Macaulay Honors Seminar, with plans to integrate it into Introduction to Environmental Science at Brooklyn College.

Cornell University/The Sciencenter

Absolutely! This partnership will continue. The actual research projects will change from year to year.

Fordham University/The Wildlife Conservation Society

Expanded Project TRUE through the funding of an NSF AISL [Advancing Informal STEM Learning] collaborative research grant …, which builds on the SENCER-ISE funded work, [and] will continue until 2019.

New Mexico EPSCoR/New Mexico Museum of Natural History and Science

NM ISE Net working with NM EPSCoR. … currently discussing ways to build the network. …considering a distributed leadership model.

Paul Smith's College/The Wild Center

The Co-PIs will look for ways to co-teach again, using the model developed by the project. The Paul Smith's Co-PI will continue to be an important partner for The Wild Center.

Raritan Valley Community College/New Jersey Audubon

Will likely continue and expand the research, outreach and management efforts in the future. The data set … will provide valuable baseline monitoring data to determine the effectiveness of management efforts (e.g., deer enclosures, hunting programs, invasive removals, etc.).

St. Mary's College of California/The Lindsay Wildlife Experience

The partnership will continue since the College has a Community Engagement requirement as part of the Core Curriculum. Faculty are indeed looking to find various

methods to collaborate with community partners. …. The Environmental Science faculty are considering numerous senior capstone projects … in collaboration with LWE. … A Pre-service Teaching Program faculty member has begun planning a collaboration to start in Spring 2017. …A Spanish faculty member has been encouraged to start a collaboration with LWE, and this Spanish translation course will help LWE generate appropriate materials in Spanish starting in 2017.

University of Connecticut/The Connecticut Science Center

The Science Center is still planning on installing and opening a genomics exhibition and program space in 2019-2020. … Retirement of the CSC (Connecticut Science Center) Co-PI … will require transition planning to determine the fesibility of establishing a sustainable collaboration that connects CSC program staff and audiences with the … University.

Building Upon SENCER-ISE

Partnership Champions

The importance of personal relationships in developing sustainable collaborations is one of the lessons learned from the evaluation of the work of the original ten partnerships. While face-to-face meetings are most preferable, efficiency and costs need to be considered. With funding from the Institute of Museum and Library Services (IMLS), NCSCE implemented "Partnership Champions," a project that added five additional cross-sector partnerships to SENCER-ISE, this time with a professional development component conducted virtually and with a shorter funding period. (See Appendix D for the listing of partnerships and project titles). Five of the original SENCER-ISE partners took on the role of "eMentors" to a new group of partners and provided guidance, based on their own experiences, on forming and enhancing collaborations. Interim results were reported by Semmel and Ucko (2017) in an overview of SENCER-ISE for the informal learning community. The authors noted the importance of jointly creating an action plan and timeline for completion of project activities. In addition, they cited the need to understand and adapt to the respective organizational cultures and constraints of the HE and ISE partners.

The "Partnership Champions" summative evaluation (RK&A 2018) concluded that the project was a positive experience for the partners, though not without challenges. Factors that supported successful outcomes included ideological alignment, flexible scheduling, openness to each other's ideas, and alignment with organizational missions. Challenges included prioritizing projects along with other job responsibilities, communication issues, and project administration requirements.

For the new eMentorship component, the RK&A report noted that

> …overall, Participants' experiences with eMentorhsip varied. The eMentorship seems to have been most useful for Partners and most rewarding for eMentors towards the beginning of the project, when Partners needed clarity on SENCER's vision and help articulating intended outcomes for their projects. …Overall, almost all Partners were grateful for their eMentors help at this stage of the partnerships. …most eMentors said Partners were "open" to hearing their advice, which they appreciated.

For future initiatives that include an eMentoring component, the report suggests that the role of the eMentor needs to be more clearly defined than it was for this short "demonstration" project. Does eMentoring work best for new projects and at the beginning of a project, and how best can eMentors be matched with projects? And, while virtual communication is efficient, some face-to-face interactions are needed.

Broadening the Network

During the 2015 SENCER Summer Institute at Worcester Polytechnic Institute, discussions about the next iteration of SENCER-ISE began. In a follow-up meeting in September, SENCER staff focused on the idea of collaboration with other established networks as a way to scale up the initiative. A Collaborative Planning proposal was submitted to the NSF's Advancing Informal STEM Learning (AISL) program. to maximize the collective impact of two well-established national STEM learning networks, Nanoscale Informal Science Education Network (NISE Net) and SENCER, by stimulating civic engagement and public understanding of science.

The one-year project was designed in three phases. In Phase I, leaders from SENCER and NISE Net focused on intensive exploration of their own and each other's networks to map regional hubs and identify pre-existing relationships between individuals and institutions of the two networks, evaluate existing communications strategies, and collect, analyze, and compare evaluation and research findings from both networks. Phase II commenced with a two-day participatory planning workshop attended by leaders from NISE Net and SENCER as well as practitioners, researchers, and administrators with a range of backgrounds and perspectives on network building in both informal and formal education. One of the outcomes of that meeting is an article in this journal by Larry Bell, senior Vice President for Strategic Initiatives at the Museum of Science in Boston and, at the time, principal investigator and director of NISE Net, articulating the role of informal learning institutions in civic engagement (Bell, 2018).

Evaluation by RK&A following the workshop revealed the following insights regarding development of network collaboration, many of which reinforced findings from the evaluation of the SENCER-ISE partnerships. Sufficient time must be allowed for the prospective partners, no matter how willing and well meaning, to learn about each other's cultures, processes, and future plans. Trust takes time to establish, as does understanding how different organizations and networks function. More time spent working together will encourage stronger relationships between the networks' leaders and practitioners. In addition, collaboration must mesh with existing plans for each network. Sufficient capacity is also required. Finally, it is critical to clarify terms, goals, and purpose before entering a partnership.

Phase III included a survey of the SENCER and NISE Net networks. The survey proposed a new collaborative project involving SENCER undergraduates who would develop informal learning resources with an ISE partner based on civic engagement. Results from 158 respondents were overwhelmingly positive, indicating strong support from both sectors for future collaboration. Fifty-seven percent of college/university/faculty/staff selected "strongly agree" when asked if participating in the project would enhance student learning; 41% were "very interested" in participating, and 47 respondents asked to be considered as a pilot institution. Among ISE professionals, 57% of respondents indicated they were "interested" in learning more about the project; 46% indicated they were "interested in participating," and 24% indicated they were "very interested."

Conclusion – Elements of a Civic Engagement Partnership

In sum, for SENCER-ISE, the following factors influenced partnership development positively:

- having the *appropriate levels of decision-making authority and organizational support* to make the partnership work (including a Memorandum of Understanding);
- identifying and sharing *common goals and missions*;
- allocating and devoting *adequate time* to build the partnership and project;
- developing from the start and continuing to update *long-term action and evaluation plans*;
- leveraging the strengths of each partner through clearly articulated roles and responsibilities; and
- maintaining *regular communication*.

Even with challenges, we found important benefits that can accrue to faculty, informal science education professionals, and learners of all ages. These are
For faculty and informal science education professionals:

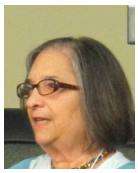
- deepened *understanding of the structure and constraints* of each other's professional practices and organizations;
- increased *respect* for the unique skills of professionals from each sector;
- expanded access to *new audiences;*
- enhanced *pedagogical methods*;
- increased involvement in *civic engagement* partnerships and expanded networks; and
- heightened view of the *role that students, particularly undergraduate students, can play* in informal science educational programs.

For learners:

- *increased engagement in learning* through connections to real-world contexts, authentic research opportunities, community activities, and place-based education;
- improved *communication skills* for students at all levels of education; and
- increased *involvement in and knowledge of compelling civic issues*.

As Amey, Eddy, and Ozaki noted in 2007, "sustainable partnerships are based on being flexible to new inputs and adjusting accordingly. …" Flexibility in responding to changes and challenges, along with adepquate funding and a sufficient time frame to plan and then to work together were certainly relevant to the endeavors of the SENCER-ISE partners and will be for similar collaborations in the future.

About the Author



Before June of 2017, *Ellen F. Mappen* retired as a senior scholar and the project director for Informal Science Education Programs at NCSCE (SENCER-ISE). She was the founding and long-time director of the Douglass Project for Rutgers Women in Math, Science and Engineering (1986-2003). Under her direction, the project received the 1999 National Science Foundation's Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. In between the women in science program at Douglass College of Rutgers University and NCSCE, she served as the director of the Healthcare Services Program at the New Brunswick Health Science Technology High School. She holds a Ph.D. in History from Rutgers University (1977), with a focus on women's history. Her dissertation focused on attitudes towards women's work in late nineteenth and early century London.

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Many individuals, only some of whom are noted here, were involved in bringing about SENCER-ISE. The late Alan J. Friedman and the then Executive Director of SENCER Wm. David Burns provided the impetus, theoretical framework, and practical ideas for implementation. The initiative could not have taken shape as it did without the initial involvement of a number of people: SENCER faculty members who came together at the March 2011 conference, along with a group of informal science educators, to examine the feasibility of cross-sector collaborations; Randi Korn of RK&A; Emily Skidmore; Cathy Sigmond; Jonathan Bucki of the Dendros Group, the conference facilitator; and Patrice Legro who was then at the Marian Koshland Science Museum. The infrastructure support provided by the staff of the National Center for Science and Civic Engagement (NCSCE) over the years was invaluable. Amanda Moodie was there for the 2011 conference. Hailey C. Chenevert, who joined the staff in early 2013 as the program assistant for SENCER-ISE, provided strong outreach to the first ten partners and general support for the initiative. Danielle Kraus Tarka, formerly Deputy Executive Director for NCSCE, provided help and encouragement. Eliza Jane Reilly, the current NCSCE Executive Director, originally served on the Advisory Board, and members of the board gave the benefit of their experience as SENCER-ISE was implemented. Eliza, along with Monica Devanas, the director of the MidAtlantic SENCER Center for Innovation, organized the Franklin & Marshall meetings that introduced Alan Friedman and David Ucko to SENCER. David Ucko and Marsha Semmel stepped in as senior advisors after Friedman's untimely death. Both offered invaluable comments on a draft of the article (as did Chenevert), and Ucko provided updates on activities that occurred after the author "retired" from NCSCE (that is, for most of the sections on evaluation of *Partnership Champions* and on "Broadening the Network"). And, finally, the formal and informal science educators who led the partnerships proved willing to take a chance on a venture that was new to most of them. Their involvement and the support of the funding agencies, the National Science Foundation, the Noyce Foundation, and the Institute for Museum and Library Services allowed NCSCE to create and learn from the initiatives.

On more personal levels, in 2006, David Burns offered a "retiree" the opportunity to be part of the SENCER initiative and always provided meaningful advice, support, and, most importantly, longtime friendship. Monica Devanas has continued, ever since we met at Douglass College, to be there as a colleague and friend. Thank you,

Marcy Dubroff, for your patience. And, last but not least, Marc Mappen, my husband of almost 50 years, has always supported and inspired me in my efforts and those of our two wonderful children.

The case history is written from the perspective of the author, who served first as the SENCER coordinator for the initiative and then as the director. All errors are entirely hers.

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Appendix A.
Developing a Framework for Civic Engagement Partnerships
(Key Themes for Implementation of Cross-Sector Partnerships)

Implementation Approaches	Sources
• Share information • Create joint experiential opportunities • Create new learning and work environments • Create new curriculum structure	From Executive Summary, March 2011 Conference Emerging Strategies: What can we do together to advance our shared vision?
• Overall concept: civic engagement • Implementation demonstrations: funding for test beds • Capacity building: mentoring for project leaders/partners • Inter-partnerships facilitation: key focus on formal & informal education partnerships/effective in-person and remote communication opportunities	From Notes from November 2011 follow-up meeting on the needs to be addressed (typed notes from November 22, 2011 meeting, Alan Friedman, n.d.). **Note:** A formal mentoring component was not part of the SENCER-ISE II support structure but an eMentoring component became the main feature in another SENCER-ISE pilot project funded by the Institute for Museum and Library Services (IMLS).
• Understanding the key elements of an ideal science and civic engagement project: identify a compelling civic question that contributes to problem solving, demonstrates respect, and values participants, promotes deep learning and discovery of new knowledge • Understanding the key elements of effective, sustainable ISE/HE partnerships, including evidence of leadership support and respect for each partner's organization (such as constraints and challenges and goals), shared program outcomes; developing a comprehensive program and management plan and an internal/external communication plan.	From Report on SENCER-ISE II Leadership Team Meeting (December 3-4, 2012), prepared by Jonathan Bucki of the Dendros Group.
As part of the selection process, applicants had to • Identify a compelling civic question; • Show how participants could contribute to solving a real problem and have an opportunity for deep learning; • Show evidence of partners' leadership support and respect for each other's organizational strengths; • Indicate potential solutions to the challenges of working across institutional divides; and • Describe how the project would fit into the core missions of each partner institution.	From RFP for Civic Engagement Partnership Awards Program **Note:** Applications were distributed between January 23 and February 13, 2013 and were due on March 15, 2013.

Appendix B:
First Ten SENCER-ISE Partnerships, with Titles and Summary Descriptions

Partnership	Proposed Project Titles/Description
Antioch College/Glen Helen Outdoor Education Center	"Biodiversity, Invasive Species and Forest Restoration: Integrating Civic Engagement in the Classroom and Outdoors" **Design** curriculum for an introductory Environmental Sciences course around the issue of biodiversity loss following non-native species invasions and also offer civic engagement
Brooklyn College/Gateway National Recreation Area of the National Park Service	"Sentinels of Shoreline Change" **Develop** collaborative learning communities around monitoring the resilience of Jamaica Bay, an urban estuary, by focusing on 7-12 grade pre-service and in-service teachers and Brooklyn College undergraduates
Cornell University/Sciencenter	"Science from the Start" Engaging Researchers, Undergraduates and a Science Museum to Reach Early Learners and Set the Stage for STEM Learning" **Create** tools for parents/caregivers to learn the science of cognitive development so that young children have the best learning environments possible
Fordham University/Wildlife Conservation Society	"Project TRUE: Teens Research Urban Ecology" **Engage** high school students in a research program in urban ecology, a sub-field of ecology that examines the interaction between humans and ecosystems in urbanized environments
Hamilton College/Green Science Policy Institute	"Chemistry and Civic Engagement: The Study of Toxic Chemicals in Everyday Products" **Develop** research opportunities for undergraduate science students that couple analytical toxicology with public policy
New Mexico EPSCoR/New Mexico Museum of Natural History	"New Mexico Informal Science Current Research Network" **Bring together** a network of informal science education institutions with a network of university-based researchers to build capacity for enhanced collaboration to engage learners in STEM issues related to water and energy
Paul Smith's College/The Wild Center	"Integrating Climate Science" **Engage** college students in a new class offering in developing targeted climate science communication to community gatekeepers
Raritan Valley Community College/New Jersey Audubon	"Integrating Citizen Science and Community College Efforts in Assessing Forest Health in New Jersey" **Involve** community college students and citizen scientists in the assessment of forest health in central New Jersey, documenting the extent of deer browse and its effect on forest structure, invasive plant species, and avian and plant diversity.
Saint Mary's College of California/Lindsay Wildlife Museum	"Facing the Future: Sharing Habitats with Wildlife" **Explore** the issue of urban habitats by having undergraduates study a specific watershed habitat in the San Francisco Bay area, design data collection methods, and create a mobile app for use at the wildlife museum
University of Connecticut/Connecticut Science Center	"Genome Ambassadors" **Create** a "genome Ambassadors" program for family audiences visiting the science center by assessing gaps in public knowledge and designing a series of genomics-related activities to address identified gaps

Appendix C.
Summary of Interview Responses by Objective From RK&A (September 2015)

Objective 1:
Higher Education (HE) and Informal Science Education (ISE) professionals increased their understanding of each other's expertise.

- Several interviewees spoke about their partner's extensive knowledge and skills. HE interviewees spoke about their ISE partner's science communication skills, and ISE interviewees spoke about their HE partner's research knowledge.
- A few interviewees said they gained a greater understanding of the structure of higher education or informal science organizations, including the barriers or constraints their partners face.

Objective 2:
HE and ISE professionals appreciate the values of each other's work and expertise.

- Many interviewees also said they would not have been able to accomplish project goals without their partner's access to and knowledge of working with a particular audience, such as undergraduates or K-12 teachers and students.
- Several interviewees (mostly from ISE) said they gained knowledge about the research their HE partners are conducting and an appreciation for how research can legitimize and support the work that they do.
- Several interviewees spoke about their partner's organizational context and resources as a strength (e.g., ISE praised their HE partners' access to analytic resources; HE praised their ISE partners' access to a real-world context).

Objective 3:
HE and ISE professionals understand elements of durable partnerships.

- Intentional goals that align with each partner's organizational mission.
  - Many interviewees said that partners need to share common goals and have a passion for the project. For instance, many partners shared a common passion for environmental protection and advocacy.
- Clear articulation of each partner's roles and responsibilities.
  - Several interviewees talked about the importance of strategic planning at the outset of a partnership. Interviewees discussed clearly defining roles, responsibilities, and expectations.
  - Interviewees discussed defining these roles and responsibilities so they leverage the strengths of each partner.
- Patience and flexibility to alter roles and responsibilities as conditions change.
  - Several interviewees talked about being open to change or course correction if a project or partnership is not achieving its original goals.
  - Interviewees tended to speak about flexibility as a personality trait (whether someone is flexible and open-minded). However, interviewees also talked about the importance of reflection in determining whether changes are needed.
- Consistent and clear communication.
  - Many interviewees said that establishing clear and consistent communication is paramount to a successful partnership.
  - Some spoke about communication as a personality trait (i.e., whether someone is a naturally good communicator); others spoke about the importance of establishing mechanisms for clear communication (phone and in-person conversations instead of email) as well as a consistent timeline (weekly, monthly, etc.).
- Other important elements.
  - Many interviewees underscored the importance of personal relationships when establishing a successful partnership, including a foundation of shared passions and complementary working styles.
  - Several interviewees mentioned resources but specifically adequate resources to allow each partner to contribute the necessary amount of time to result in a successful project.
  - A few said partnerships need time to work out kinks and see results. These interviewees also discussed the importance of funders' recognizing that time (at least a few years) is necessary to create a successful project.

Objective 4:
Other HE/ISE professionals value the partnership.

- Several interviewees talked about other faculty or students who became interested in collaborating with the ISE partner or in the SENCER model for their course.
- A few interviewees said their project collaboration brought them recognition or credibility from other departments or individuals. In one case, this recognition brought additional funding.

Appendix D.
SENCER-ISE - Partnership Champions – Partners and Projects

Partnership	Project Title
Eastern Michigan University/Ann Arbor Hands-On Museum	Engaging Children and Families in Authentic STEM Activities: A Cross-sector Partnership to Promote Equity in Informal Science Education
Lincoln Memorial University/Abraham Lincoln Library and Museum	Science, Human Geography, and Environmental History: Recognizing Humans as Part of Nature
Rider University/Stony Brook Millstone Watershed Association	SENCER-ISE-K-12 Partnership Explorations
Towson University/National Aquarium	TEAB (Teaching Environmental Awareness in Baltimore)
Wheelock College/Charles River Watershed Association	A Citizen Science and College Student Partnership to Assess Stream Health in the Charles River Watershed