



SCIENCE EDUCATION
& CIVIC ENGAGEMENT

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About the Journal

Science Education and Civic Engagement: An International Journal is an online, peer-reviewed journal. It publishes articles that examine how to use important civic issues as a context to engage students, stimulate their interest, and promote their success in mathematics and science. By exploring civic questions, we seek to empower students to become active participants in their learning, as well as engaged members of their communities. The journal publishes the following types of articles:

- ▶ **Book & Media Reports**
- ▶ **Point of View**
- ▶ **Project Reports**
- ▶ **Research**
- ▶ **Review**
- ▶ **Science Education & Public Policy**
- ▶ **Teaching & Learning**

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SCIENCE EDUCATION
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AN INTERNATIONAL JOURNAL

From the Editors

We are pleased to announce the Summer 2018 issue of *Science Education and Civic Engagement: An International Journal*.

Highlighting the value of international service, **Courtney Cox, Sarah Lenahan, Patricia Devine,** and **Panagiotis Linos** (Butler College) describe collaboration among the College of Pharmacy and Health Science, the College of Liberal Arts and Science, and Barnabas Task, a non-profit organization. Students have the opportunity to travel to the Dominican Republic to participate in service activities with medical and dental professionals. They work with community leaders to convey public health information on topics such as nutrition, exercise, smoking cessation, and mosquito-borne illnesses, so that the knowledge can be disseminated throughout the community using local networks. This experience enables students to develop their cultural awareness and illustrates the importance of local knowledge and collaboration in promoting social change.

Susan Huss-Lederman, Prajukti Bhattacharyya, and **Brianna Deering** (University of Wisconsin-Whitewater) describe their participation in the Do Now U Project, a collaboration between the National Center for Science and Civic Engagement and KQED Public Media. The project paired two courses, Environmental Geology and College Writing in English as a Second Language, and required students to write blog posts on environmental topics. After all the posts had been read and analyzed, one was chosen for publication on the web. This project provides students with valuable opportunities to research open-ended questions with important social impact while learning to collaborate and to communicate effectively.

Ellen Mappen (National Center for Science and Civic Engagement) provides an interesting case history of the beginnings of the SENCER-ISE project, which is a structured collaboration between SENCER and practitioners of informal science education (ISE) based on issues of civic engagement. This account describes the mutually beneficial synergies between formal and informal education and includes evaluation results that demonstrate the effectiveness of project partnerships.

The issue concludes with an insightful review by **Katayoun Chamany** (Eugene Lang College, New School) of a report from The National Academies entitled *Integration of the Humanities and Arts with Sciences, Engineering, and Medicine: Branches from the Same Tree*. The review situates this new report in a historical context and examines how the integration of disciplinary perspectives from the arts and humanities can enhance science education and motivate students to persist in their scientific studies.

We wish to thank all the authors for sharing their accomplishments with the readers of this journal.

Matt Fisher
Trace Jordan
Co-Editors-in-Chief



PROJECT REPORT

Using the SENCER Approach in Collaborating Across Disciplines: Participating in Do Now U

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Introduction

This project report details a pilot venture that paired two undergraduate courses at the University of Wisconsin-Whitewater: (a) Environmental Geology, an upper-division general education science course, and (b) College Writing in English as a Second Language (ESL), a first-year composition course for international students whose second language is North American English. Students enrolled in these two courses collaborated in writing blog posts on scientific topics with societal repercussions as part of the Do Now U project, a joint initiative between the National Center for Science and Civic Engagement (NCSCE) and the education division of KQED Public Media. Collaborating in this project enabled students to

use the discourse of science in authentic communication with an identified audience while conducting a group project. Evaluation shows that students enjoyed this self-directed learning experience, using digital media to communicate and to create a digital document on a scientific and social issue.

NCSCE sent a call for participation (<http://ncsce.net/donowu-spring-2017-ncsce-kqed-now-accepting-applications-for-new-do-now-u-creators/>) to college educators in fall semester 2016. In early January 2017, interested participants attended a webinar on project participation guidelines. Instructors also selected a date for submitting their posts during spring semester 2017. They

then formed student teams, each of which proposed and decided on a topic, formulated a discussion question, and ultimately composed a blog post for the KQED Do Now U website. KQED furnished a template for blog posts, which required background information and explanation of both positive and negative implications of the topic at issue. Posts also included links to relevant videos, images, and other reliable online resources. KQED education staff selected one blog post per participating institution. Once published to the web, the posts were open for public discussion and comments.

Collaborating on a Do Now U Post at the University of Wisconsin-Whitewater

Naturally, Environmental Geology and College Writing in ESL, although both undergraduate courses, differed in several ways. The two sections of Environmental Geology, taught by Bhattacharyya, each enrolled 24 students and met twice a week in 75-minute blocks. The course follows the SENCER approach to inquiry, encouraging students to investigate unsolved problems relevant to today's society, so that they not only develop content knowledge, but also improve critical thinking skills (Burns, 2002). Environmental Geology is a hands-on, experiential course, required for environmental science majors with an emphasis in the geosciences, but open as an elective to non-majors. Therefore, the students enrolled in the course represented a variety of academic backgrounds and interests. The course is thematically organized to inspire further exploration of topics chosen by students.

College Writing in ESL, team-taught by Huss-Lederman and Deering, enrolled 13 students and met four days a week in 75-minute blocks. The majority of the students who enroll in this course are international students, new to the United States and to university study. They represent a broad range of English proficiency and, like most first-year college students, are novice academic writers. Typically, this writing course has been organized thematically, often with human rights or social responsibility as broad topics, and so developing a semester-long environmental theme for the course was a natural fit. One goal of this composition course is to be an onramp to academic success at the university. Largely, this means providing opportunities for students to improve academic English proficiency, while simultaneously helping students to access programs that position them for success. Participating

in this project enabled international students to interact with native English speakers; both groups completed an academic research project, using the SENCER approach to inquiry to enhance college-level, academic literacy in English. By the end of the project, Deering and Huss-Lederman had become advocates for the SENCER approach, continuing to develop project-based learning opportunities for their students throughout the semester even after the collaborative project ended.

In each course, the Do Now U project served a different purpose. In Environmental Geology, the assignment took on a minor role. Participation gave students the opportunity to engage in both writing to learn and writing for an audience beyond their teacher through a novel, small-stakes assignment. It also simulated an increasingly common professional situation—asynchronous collaborative writing in a medium less commonly used in a course assignment, an academic blog post to a website external to the university. Students were placed in groups based on their topic of interest, so students from both sections were required to work together, and in some cases with international students from the writing course. Students developed blog posts outside of class, but incorporated their research into class discussions. Geology students received feedback on topics along with possible questions from Bhattacharyya as comments on homework, and they were free to contact any instructor with questions concerning the posting assignments.

Since the college composition course is devoted to argumentative writing that synthesizes information from external sources, the Do Now U project took on a major role because it required international students to practice these academic skills. Reference librarians offered students a weeklong seminar in identifying and evaluating web-based resources. Students read and wrote short essays, utilizing cause and effect and problem/solution structures. Reading assignments also emphasized summarizing, paraphrasing, and identifying and interpreting quotations—all skills essential to academic writing. Generally, two international students were assigned to Do Now U project groups of two or three geology students, although international students with stronger English proficiency or a more autonomous learning style could decide not to have a composition classmate as a partner. However, for many international students, having a

classmate as a partner in this project gave them confidence in the research and collaborative writing process. In fact, the international students continued to develop their English academic writing skills after this project was finished, either by continuing with their original ideas or examining a related environmental topic, which they then presented as posters during the campus Sustainability Day in April.

Although the goals of the geology and English courses were not the same and incorporated the Do Now U project differently, courses had to follow the same timeline for preparing posts. To facilitate the online writing process, instructors also assigned students roles, such as background writer, pro argument or con argument writer, editor, and media finder. Three common collaborative face-to-face sessions were held for students to complete the post together. Ultimately, UW-Whitewater submitted 16 blog posts for consideration. On March 15, 2017 the entry, "Do the Benefits of Aquaculture Outweigh Its Negative Impacts?" (<http://ncsce.net/do-now-u-do-the-benefits-of-aquaculture-outweigh-its-negative-impacts/>) was posted.

Evaluating the Project

An online evaluation with questions targeted to each course was sent to all students in March, 2017. There was nearly a 100% response rate by geology students. Thirteen students were enrolled in English 162 when the project started, but only eleven completed the course, and six completed the survey. The findings are summarized below.

Geology Students

In the environmental geology course, collaborating on a blog post for a public media outlet was a novel experience, from determining a topic and refining a discussion question to writing a backgrounder that included links to further information.

1. 95% indicated that they had learned something new about an environmental topic that they had chosen and researched themselves, with some commenting that they had come to understand new perspectives and to identify their own biases.
2. Many students indicated that working in a group offered them new perspectives on how to work with

others; those who worked with international students appreciated the opportunity to do so.

3. Students enjoyed working with multimedia resources and developing a blog post, as opposed to writing a traditional research paper.
4. Some students found group work to be frustrating when group members did not contribute to the team effort.

International Students

Collaborating to write a blog post for a public media outlet was also a novel experience for the international students. The emphasis in this assignment, as well as in others in the course, was to develop and strengthen collegiate writing proficiency in English. Students were asked to reflect on their development.

1. On a scale of "not confident" to "very confident," international students were asked to reflect on their growth as academic writers in English. All students indicated that they felt "somewhat" to "very confident" in their ability to locate appropriate academic resources and to evaluate their reliability.
2. On a scale of "not confident" to "very confident," students indicated that they felt confident providing academic summaries of resources and preparing counterarguments.
3. All students reported that their academic vocabulary had improved.

None of the students indicated disappointment if their team's work was not chosen for publication. Overall, the experience was positive for students enrolled in both courses.

What the Instructors Learned

This pilot was the first time that these three instructors collaborated on a public writing project, let alone one that paired upper-level students with novice academic writers who communicate through ESL. Observations of students throughout the project, as well as student survey results, led to the following conclusions:

1. Using the template provided by KQED and reviewing past posts to understand how to complete the assignment from the beginning focused the writing process

for all students and made assigning writing roles to students easier. Furthermore, the template's structural guidelines freed students to focus on refining their questions and finding relevant resources instead of wondering how to organize the information.

2. Making the theme of the English course environmental sustainability and registering for a blog posting date mid-semester gave the first-year international students time to build background knowledge in order to be strong partners to the geology students. All students ultimately shared common content knowledge, which leveled the playing field for the assignment.
3. Assigning international students to write the negative position on a topic helped them to conceptualize counterarguments, an important skill in argumentative writing.
4. Geology students in groups with international students enjoyed the opportunity to meet and work with students from other countries.
5. All students appreciated the chance to share information with a broader audience outside of their courses.
6. Although many students liked building a document by communicating online, they also appreciated the face-to-face work. Face-to-face meeting in the university library allowed all students to review work together.

Changes for Future Projects

Overall this pilot worked well; however, certain modifications would improve the structure of future collaborative writing projects. For example, scheduling the English course and the geology courses at the same time of day would allow for more convenient face-to-face collaboration among all students as a learning community. Although most students enjoyed this assignment, some were frustrated when not all group members pulled their weight. Because this also happens in the workplace, students need to know how to manage such situations and how to take responsibility for their specific roles on a team project. Restructuring the course assignments to emphasize individual accountability to the group would help students to develop this skill. Students would benefit from reflecting on the experience of working in groups and learning how individual actions affect the team.

Discussion

Both collaboration and open-ended research-based projects are high-impact practices (HIPs), noted for promoting strong learning outcomes in higher education that translate to participation in a globalizing society (Kuh, 2008). Indeed, an analysis by Kilgo, Sheets, and Pascarella on the effectiveness of HIPs on the goals of liberal arts education indicates that these two practices are "... significant, positive predictors for a variety of liberal arts learning outcomes" (2015, p. 522). Students participating in the Do Now U project worked together to research issues in which society affects the environment. Such learning practices fall within the domains of cognitive and interpersonal competence, integral to 21st-century skills (National Research Council, 2012). Project-based learning is also a natural fit in the SENCER paradigm, as it promotes student-centered, self-directed, deep examination of issues.

Additionally, students participating in groups composed of both U.S. and international students experienced working with individuals from a culture other than their own, an important component of intercultural competence (Kuh, 2008). Although students enrolled in Environmental Geology would have been able to carry out this project on their own, sharing the project with first-year international students enabled all students to improve intercultural competence within an international academic community. The ability to work as a team, not only face-to-face but also online, is an important competency in the global workforce (Moore, 2016).

In the English course, working with unsimplified, authentic texts and communicating with native speakers in English allowed students to conduct research and to write for a specific purpose and audience far beyond their ESL class. Such practice helped them to focus on the intellectual purpose of researched writing rather than on the mechanical aspects of citation and reference, which, although important, should not occupy the forefront of writing to learn (Howard and Jamieson, 2014). Collaborating with students in the geology course on this project required ESL students to become knowledgeable about an environmental concern and to communicate with others using both academically and socially appropriate language in speech and writing. Furthermore, project-based learning naturally promotes the use and development of the four language skills (speaking, reading, writing,

and listening) and subskills (vocabulary, grammar, and pronunciation) in an integrated way and fosters learner autonomy (Beckett and Slater, 2005). The sustained opportunity to use academic language beyond the English composition classroom in a scientific theme put these international students on track for academic language development and learning that would serve them in courses beyond this one. Such educational practices may become increasingly important as the number of ESL students enrolled in English-medium institutions of higher education around the world grows (Fenton-Smith, Humphreys, Walkinshaw, Michael, and Lobo, 2017).

For the geology students, the experience of asynchronous, collaborative writing was a gateway into an increasingly common mode of professional communication in both academia and the workplace. Students were also placed in the novel situation of sharing information that they had learned independently with a wider audience. Although the project was a low-stakes assignment in terms of the effect on the course grade, students engaged in several HIPs—collaborative group work, working across cultures, and a writing-intensive assignment, while engaging in self-identified, open-ended questions where science and social responsibility came together.

Conclusion

A SENCER course in the sciences is different from a composition course that uses science topics as a springboard to academic writing, yet the opportunity to communicate about science can reach beyond science courses. Collaborating on Do Now U demonstrated how this type of bridge worked—bringing group writing to a science course and introducing SENCER practices into a composition course for international students. Further, it exemplifies how collaboration between the humanities and natural sciences, using a SENCER approach, benefitted students at different stages of university education.

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Brianna Deering (deeringb@uww.edu) is a Lecturer in the English Language Academy at the University of Wisconsin-Whitewater. Educating students has been her passion for the last 25 years. She began her teaching career in elementary education and transitioned to adult education, with the last five years being at the college level. She has taught a variety of ESL courses, from introductory to advanced English, as well

as English for business communication and the healthcare system. She has organized conversation groups, service learning projects, and community outreach programs as ways to expand the cultural knowledge of her international students.

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REVIEW

Review of National Academies of Science, Engineering, and Medicine (NASEM) Report, Integration of the Humanities and Arts with Sciences, Engineering, and Medicine: Branches from the Same Tree

Katayoun Chamany

Eugene Lang College of Liberal Arts at The New School

On May 7, 2018, The National Academies of Science, Engineering, and Medicine (NASEM) released a report, *Integration of the Humanities and Arts with Sciences, Engineering, and Medicine: Branches from the Same Tree*, which champions the integration of arts and humanities with STEMM (STEM + Medicine). An ad hoc committee, comprising 22 experts spanning education, industry, and policy, met over three years gathering best practices and hosting workshops and open meetings. The committee developed a consensus report and a compendium of more than 200 examples (<https://www.nap.edu/resource/24988/AH%20STEMM%20Programs%201010.pdf>), some of which are SENCER-related projects. Kristin Boudreau, Professor and Department Head of

the Humanities and Arts at Worcester Polytechnic Institute, is at the helm of SENCER's New England Center of Innovation and was a member of the committee charged with developing the consensus report.

The timing of this project and the publication of the report are of import. The project was launched on December 2, 2015, when Obama was in office and a strong focus on STEM education in community colleges was established as a priority. The December workshop, funded by the Andrew Mellon Foundation and hosted by the National Academies of Science Board on Higher Education and Workforce (BHEW) (<http://sites.nationalacademies.org/PGA/bhew/index.htm>), was attended by 110 artists, engineers, educators, policy makers,

and industry experts. The ensuing project garnered additional funding from the National Endowment for the Arts (NEA) and the National Endowment for the Humanities (NEH).

Despite cutbacks under the new administration, the project endured and included an investigation of a wealth of resources, models, and institutional examples of organizational and pedagogical change to determine how integrated learning can serve all students. Perhaps, now more than ever, given the growing chasms in our society, integrated learning is essential if we are to provide our students with the tools to address social change, and the findings of this report are useful. During the question and answer period of the meeting that launched this NASEM report, James Grossman, the Executive Director of American Historical Society, commented that "thinking about teaching in and beyond a discipline has to become as important as thinking about research in and beyond a discipline." He argues that the challenge of promoting interdisciplinary teaching may require educators and students to reconsider how they identify; that we need to rethink about ourselves (NASEM, 1:12 min time stamp).

The project was spearheaded by the BHEW and other divisions and units within the NASEM, with the specific goal of providing an evidence base for the integration of humanities and arts and STEMM to inform "new projects aimed at improving the understanding and application of STEMM toward the social, economic and cultural well-being of the nation and planet." The committee analyzed evidence to determine how STEMM experiences enhance the knowledge base of students studying the arts and humanities, so that they make sound decisions across all professional fields and contribute to a vibrant democracy. Likewise, the committee also analyzed evidence regarding the value of including arts and humanities perspectives in STEMM academic programs to produce more effective communicators, problem solvers, and leaders, who recognize the broad social and cultural impacts of STEMM. In both instances, the hypothesis being tested was that student populations could expand their skills of critical thinking, creativity, and innovation using these complementary perspectives and different ways of knowing to develop meaningful lives and careers (see Chapter 6 for examples).

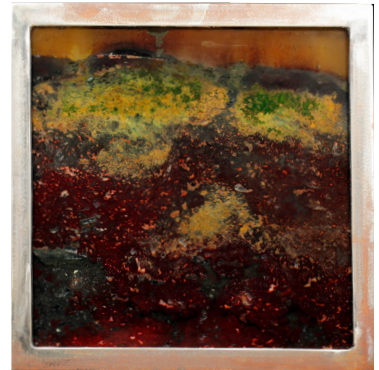
One example in particular stood out because of its effect on retention of the diverse student population served by the City University of New York (CUNY) community colleges. The Guttman Community College's two-semester City Seminar, fulfills the general education requirements of quantitative reasoning, critical thinking, writing, and reading and has a 27% completion rate as opposed to the 4.1% completion rate of other CUNY community colleges. They credit this success to their interdisciplinary approach, which meets all the general education requirements in one course, rather than distributing them among many.

A closer look at the charge of the NASEM committee suggests that on a national level we are finally beginning to address the criticisms of social science and humanities scholars regarding the 1945 report titled *Science: The Endless Frontier*. This report championed the unfettered advancement of STEM with no attention given to the valuable insights provided by humanities and social science perspectives. Vannevar Bush, Director of the Office of Scientific Research and Development, authored this six-chapter report as a response to President Franklin D. Roosevelt's request to expand the goals and benefits of science beyond its wartime focus on the military. Additionally, the report argued that science learning should be more accessible and that scientific research should be more transparent to the American public. The report led to the establishment of the National Science Foundation, with the goal of ensuring national security, economic progress, and cultural growth, akin to the current charge by BHEW.

Some of the criticisms of the *Science: The Endless Frontier* report are contained in a collection of papers published by scholars in the humanities and social sciences on the 50th anniversary of its publication. Highlights appear in *Science the Endless Frontier: Learning from the Past, Designing for the Future* (https://cspo.org/legacy/library/090729F3GD_lib_BushconferenceHi.pdf), which presents papers from a conference series held between 1994 and 1996 and includes responses and updates to the Bush Report, arguing that a lack of integrated knowledge would mean the demise of a STEM-centric approach to learning. Similarly, in "Is it possible to just teach biology?" (Horton & Freire, 1990), educational philosopher Paulo Freire and founder of the Highlander School Myles Horton also argue that to teach STEM

Wightman, Jenifer. Gowanus Canal. Portraits of NYC. Steel, glass, silicone, eggs, newspaper, chalk and mud from the Gowanus Canal, Brooklyn, NY. 15"x15"x2". Installed on Governor's Island for the Swing Space Residency hosted by the Lower Manhattan Cultural Council, NY, NY. September-December 2012. One-week and three-month images alongside three-month image printed on textile. Copyright Jenifer Wightman. (www.audiblewink.com/gowanusbox.html)

Jenifer Wightman, a scientist and artist, creates "color fields" that combine methodologies from art (Mark Rothko's color fields) and science (Winogradsky biochemistry columns) to showcase ecological succession, biodiversity, and resilience of bacteria growing in a Superfund site. Wightman writes about her process using traditional formats such as the peer-reviewed journal research article where she describes her scientific method, and supplements this with drawings, journal entries, images, and process photographs. Her approach to integrating art, humanities, and science mixes content and method. Her artwork, videos, and articles are used as resources for courses in the first-year core curricula at Parsons School of Design, Eugene Lang College for Liberal Arts at The New School and Science+Art+Design workshops hosted by the New School for the community. Students apply this project to their learning about water quality testing using color detection for microbial metabolites, sustainable dyeing of textiles with microbial pigments, and visualization techniques that use light and biological processes to make the invisible visible.



without social context is a mistake. At the NASEM meeting to launch the *Branches* report, some committee members remarked how these sentiments led to Leadership in Science and Humanities opportunities funded by the Fund for the Improvement of Postsecondary Education (FIPSE) and the NEA in the 1990s, which were not sustained but must now be renewed.

The NASEM report recognizes those early criticisms and acknowledges that change is underfoot. The evolution of their charge is apparent with its emphasis on looking at integration as a two-way phenomenon that will improve the cultural well being of not only the nation, but also the planet. Over the last thirty years, curricular resources for integrated learning have moved beyond the social sciences to include the necessary perspectives that are central to the arts and humanities. The STEAM (STEM +Arts) and STEAMD (STEM+Arts+Design) movements take steps in that direction, with concrete collaborations and multi-institutional efforts underway. Examples include the Vertical Integrated Projects Initiative (VIP), with a strong focus on research, innovation, and design; Creativity Connects (<https://www.arts.gov/50th/creativity-connects>), funded by the NEA in 2016, which connects academic institutions with community partners, businesses, and artists; and the Bridging Cultures initiative

(<https://www.neh.gov/divisions/bridging-cultures>), launched in 2012 by the NEH. That two of these successful programs—Georgia Tech VIP (<http://www.vip.gatech.edu>) and Montgomery College Global Humanities Institute (<https://cms.montgomerycollege.edu/globalhumanities/>)—have connections to SENCER is no surprise

Though curricular resources are emerging, a quick review of the archived video footage of the meeting that accompanied the launch of *Branches from the Same Tree* reveals two things. Committee Chair David J. Skorton, Secretary of the Smithsonian, chuckled multiple times as he revealed that the committee was governed from the ground up, reflecting the horizontal nature that often accompanies interdisciplinary learning. He claimed to have little authority to rein in the committee members, and instead allowed their collective expertise to guide the process. The second interesting reveal is that the committee found little research in the way of "controlled" studies regarding how integrated learning influences student learning outcomes. In response to an attendee's question regarding challenges (see Chapter 4 and the video link [http://sites.nationalacademies.org/PGA/bhew/branches/PGA_185825]), Chair Skorkin mentioned the number of confounding variables that are part of each

student's life and make controlled studies impossible. In Chapter 4 of the report, the authors also remark that implementation of integrated courses can involve multiple variables that are difficult to tease apart or control, as they are distributed across different institutions and adapted/adopted by different faculty members. Moreover, the integrated course is not always a single treatment or intervention, but instead involves multiple factors, such as content, methodology, pedagogy, and assessment. Despite the limited evidence, the committee members believe that what they have seen is promising for students at two-year and four-year undergraduate institutions, as well as those in graduate programs. Ashley Bear, the NASEM Study Director, feels that evidence gathered from the responses to the "Dear Colleague Letter" provide a rich collection of different methods and approaches to showcasing student learning, as do the comments gathered from employers and alumni, which are encapsulated in Chapter 6 of the report.

In Chapter 3 of the *Branches* report, "What is Integration?" the authors are careful to point out that disciplinary knowledge without synthesis does little to support the understanding of emergent ideas. Stephen J. Kline's work on multidisciplinary learning is cited and his attention to emergence reminded me of another important piece of work, by David Edwards, arts scientist and author of *Artscience: Creativity in a Post-Google Generation* (2009). Kline and Edwards advocate thinking more creatively about how arts, social science, and natural sciences can lead to new ways of doing and thinking. Yet many examples of integration remain at the level of service to one or the other discipline, which the report describes as "superficial." For example, many courses seek to use the arts to communicate scientific knowledge or practice, or they use scientific methods to illuminate art practices as seen in art conservation. As the chapter illustrates, integration is a developmental process. As one moves from multidisciplinary to interdisciplinary to transdisciplinary, the emergent practice, method, or ideas can transform and morph an existing discipline or field, or produce a new one, or use a wholly different integrated approach to addressing a crisis, as seen with Mary Beth Hefferman's work on the PPE Portrait project, which is designed to address the lack of humanistic interaction in highly contagious infectious disease treatment centers (p. 13 of the report).

Many attendees at the meeting that launched the report's publication on May 7, 2018 were interested to learn of any potential opposition to the proposed integration model. Committee Member Bonnie Thorton-Hill remarked that many of the best models could be found outside traditional department structures, in institutes and centers. Because investment in infrastructure to support these initiatives may be a significant hurdle for some institutions, many authors of the report and attendees at the meeting saw this as an opportune time for the federal government to take the lead and stimulate implementation and research through funding streams and new initiatives. Further, the committee stressed the need to refrain from draining disciplinary resources but instead to build upon them. Another concern raised by attendees was how this work would be valued in promotion and tenure reviews, federal funding, and national accreditation standards, and some suggestions designed to address these inquiries are provided in Chapter 5 and on pp. 7–8 of the summary report.

Perhaps what was most refreshing about the attendees and the authors of the *Branches* report was the diversity of disciplinary perspectives, lived experiences, cultural and ethnic backgrounds, and attention to the changing nature of our student populations. Many of the examples presented in the chapters and mentioned at the meeting highlighted the ways in which integrated learning can lead to the development of sound decision-making, empathy, and awareness and tolerance for different ways of knowing and different points of view. These approaches align with the SENCERized approach to teaching and learning.

I would like to end this review with the compendium of more than 200 examples (<https://www.nap.edu/resource/24988/AH%20STEMM%20Programs%201010.pdf>) that is provided as a supplement to the *Branches from the Same Tree* consensus report and the "Gallery of Illuminating and Inspirational Integrative Practices in Higher Education" (<https://www.nap.edu/read/24988/chapter/16>). The latter includes boxes and images scattered throughout the report, as well as a large collection appearing at the end of the report offering images and descriptions of artistic and humanistic scholarship, education, and practice that have been inspired, influenced, or supported by STEM knowledge, processes,

and tools. A few SENCER projects are included in the compendium; some notable exceptions are highlighted below.

In keeping with the proposed next steps presented in the *Branches* report, Gillian Backus and Rita Kranidis, SENCER Leadership Fellows, have launched a STEM-Humanities Consortium effort (<http://ncsce.net/sencer-leadership-fellows-look-for-community-input-on-stem-humanities-consortium/>). I encourage our SENCER community to take up the charge of contributing to this effort and to think carefully about how best to organize a multi-institutional research effort to assess the effect of integration on student learning, as described in this report. A list of possible research questions to drive such projects appears on p. 92 of the report.

Some examples:

- **From SENCER Hawaii** (<https://sencerhawaii.com/about-us/>): Traditional Hawaiian values align closely with SENCER's ideals and objectives for sustainability and stewardship of our community; curricular resources draw on ethics, culture, and history.
- **From SENCER Northern Virginia Community College** (<http://www.nvcc.edu/news/press-releases/2014/the-creative-mind-art-science.html>): "The Creative Mind: The Intersection of Art and Science."
- **From SENCER College of Liberal Arts Auburn University** (<http://ncsce.net/on-campus-auburn-students-research-impact-of-music-on-health-outcome>): The impact of music on health.

About the Author



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for Extraordinary Contributions to Citizen Science from the National Center for Science and Civic Engagement.

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RESEARCH

Learning Without Borders: Qualitative Exploration of Service-Learning

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Introduction

For the last four years, pharmacy, physician assistant, pre-medicine, and nursing students enrolled or associated with Butler University's College of Pharmacy and Health Sciences (COPHS) and College of Liberal Arts and Science (LAS) have partnered with Barnabas Task to travel to the Dominican Republic (DR) for an annual medical mission trip. Barnabas Task, a nonprofit organization founded in Fort Wayne, Indiana, conducts multiple service trips every year with dental and medical professionals, as well as other volunteers, to the Dominican Republic, Cuba, or Guatemala. Barnabas Task's mission is

"community transformation through leadership development" (Barnabas Task, 2013), and they utilize community health evangelism (CHE) to accomplish this goal. During these mission experiences, students have the opportunity to assist medical providers through patient triage, medical scribing, and medication dispensing. Students also work directly with community leaders to educate them on public health topics including nutrition, exercise, smoking cessation, dental hygiene, and mosquito-borne illnesses. These community leaders can then educate others and spread the knowledge through grass roots. This philosophy of developing a relationship with host communities

mirrors the work of Olenick and Edwards (2016). Their article in *Nursing for Women's Health* concludes that short-term health missions are more effective when they focus on a "long-term commitment rather than a quick fix."

Students and volunteers work to form long-term commitments not only by educating community leaders in the DR, but also by working with local students who act as translators within the clinic. Most of the students who made the trip lacked fluency in Spanish, and all volunteers are therefore provided with a translator. Every clinic day, students from Oasis Christian School, which is a part of Santiago's private school system, help translate for the students and medical volunteers. Students from the local Catholic medical school, Pontificia Universidad Católica Madre y Maestra (PUCMM), also join the clinic daily to translate, triage patients, and fill prescriptions. Some students keep returning to the clinic even after they graduate medical school and volunteer as healthcare providers to help their community. This includes a provider who has made a commitment to visit the clinic quarterly to follow up with patients whose medications for chronic diseases such as diabetes and hypertension may require adjustments. Interactions with the DR students and providers adds another layer of collaboration, where students can learn from one another while caring for underserved populations.

To strengthen these long-term commitments, Barnabas Task turned to Butler University Fairbanks Center for Communications and Technology in 2015 with the goal of developing an electronic means of carrying medical information during the mission trips and accessing these records during future medical trips, thus starting the relationship between Barnabas Task and the Engineering Projects in Community Service (EPICS) course at Butler University. Computer science and software engineering students enrolled in this course meet biweekly to complete a "supervised team software project for a local charity or non-profit organization" (Linos, 2012). This relationship initiated the development of an Electronic Medical Records (EMR) application prototype, which runs as an iOS app. Students in the EPICS course collaborated with Barnabas Task to meet their needs to provide continuity of care and formed a relationship with healthcare students from COPHS to format the iPad application. Currently in the fifth semester of collaboration

between EPICS, Barnabas Task, and COPHS, the application continues to be updated and built upon and is now a stable prototype of a bilingual EMR that can preserve patient records, transcribe prescriptions to the clinic's pharmacy, and maintain medication inventory.

Data on the benefits of EMRs are plentiful. A systematic review published in September 2017 established how EMRs significantly improve documentation of clinical information and enhance quality outcomes in the long-term acute care setting (Kruse et al., 2017). Similar effects can be seen in the inpatient hospital setting. Khalifa and colleagues found that after EMRs had been implemented in their health system, there was "an increase in information access, increased healthcare professionals productivity, improved efficiency and accuracy of coding and billing, improved quality of healthcare, improved clinical management (diagnosis and treatment), reduced expenses associated with paper medical records, reduced medical errors, improved patient safety, improved patient outcomes and improved patient satisfaction" (Khalifa, 2017). A comprehensive review by Keasberry, Scott, Sullivan, Staib, and Ashby (2017) ascertained that EMRs enhance patient safety by including alerts about drug interactions and adverse drug reactions. The utilization of an EMR also improves patient outcomes by increasing to guideline recommendations. EMRs stateside improve hospital processes and patient care, which explains the DR clinic's need to obtain an EMR to improve clinic processes abroad.

We conducted a thorough search and determined that there are no similar efforts currently described in the literature. However, there are publications that discuss collaborations and active learning as well as the benefits of these types of interactions. A group at the University of Wisconsin created interprofessional groups that served both a local community and a global community in Malawi. They concluded that students had increased their level of understanding in values and ethics, roles and responsibilities, and teamwork as a result of the experience (Dressel et al., 2017). Johnson and Howell (2017) also discuss the benefits of service-learning and interprofessionalism. Healthcare students from different programs including pharmacy, medicine, physical therapy, and nursing traveled to Ecuador for a service-learning opportunity. The authors explain how the students had to work through communication barriers both with their patients

and with other healthcare professionals, all of whom spoke a different language. Increasing cross-cultural and interprofessional learning will be crucial in the future due to the diversifying healthcare system. A nursing cultural simulation developed by Carlson et al. (2017) connected nursing students in Hong Kong and Sweden and ultimately ascertained that the intercultural experience developed collaborative skills, including communication, between the two groups of students as they worked to complete a case study. In our literature review we found plenty of interprofessional articles; however, the literature lacks information on students from different colleges collaborating on a project to better the community they plan to serve. Professionals in the healthcare field are being exposed to a wide array of people with different educational backgrounds, and it is important to confront these language and knowledge barriers.

This study was developed in order to (a) assess how information technology affects clinic processes, (b) identify student learning and cultural awareness when collaborating with students from different colleges and globally, and (c) understand how global missions are viewed by the communities being served.

Methods

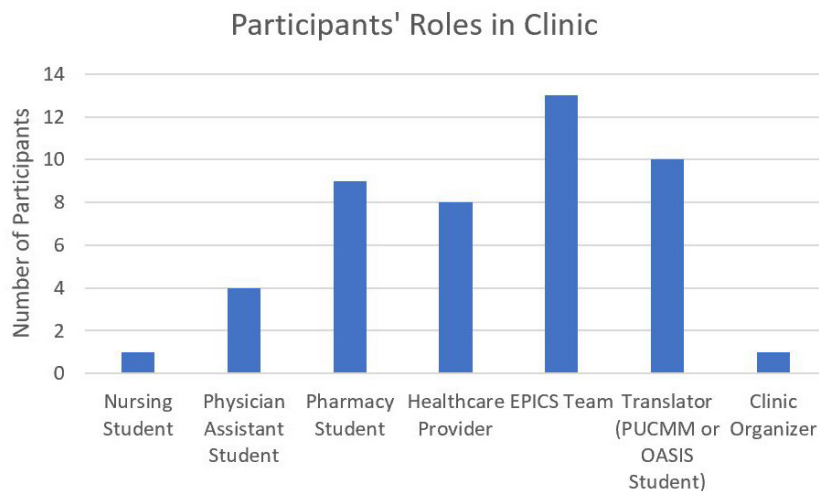
When commencing this project we hypothesized that students would gain knowledge about how to work with other professionals, increase their skills within their various areas of expertise, and develop cross-cultural awareness while helping to improve a community's health with the creation of an EMR. The institutional review board approved the anonymous survey that was sent to all sixty-five volunteers who worked in the underserved clinic in the DR and the EPICS students who helped develop the EMR but were unable to go to the DR. Using Qualtrics (Qualtrics, Provo, UT, May 2017), an online survey platform, the survey was created to consist of multiple choice and free response questions regarding demographics, role in the project, and experience in the clinic. Utilizing skip logic, participants answered questions written specifically for their role in the clinic (for example, healthcare student; computer science student; translator; etc). The original survey questions are listed in appendix 1. Results from the open-ended questions on the survey

were analyzed based upon common themes and similar wording found throughout the participants' answers. The institutional review board also approved an anonymous quality survey all patients at the clinic eighteen years of age and older had the opportunity to take. Those who participated answered four questions about their time spent in the different stations of the clinic, whether they would recommend the clinic to their friends or family members, and whether they believed the clinic brought hope to the community. If an entire family came to the clinic, one person from the family could complete the survey for their household. In total, 95 patients completed the survey using SurveyMonkey.

Results

Of the 65 clinic volunteers who were sent the survey, 51 elected to complete it for a response rate of 78.5%. The specific roles for each of the responses are illustrated in Figure 1. Starting with student learning, knowledge was gained through this experience through the various collaborations. The EPICS team, healthcare professionals, and Dominican volunteers all had participants who reported their top learning experience was in communication. Three out of five of the EPICS team members stated their top two non-technical learning experiences were in communication and teamwork. Students are also retaining the knowledge from this experience, as five out of five responses by the EPICS team stated they have used the knowledge gained in this course outside school or in another class. One EPICS member conveyed the importance of this class being able to "bridge the gap between those who are very technical, with little healthcare experience, and healthcare clinicians who possess little technical expertise." Examining the development of technical skills, all of the EPICS students grew in both Xcode (Apple's software development environment) and Swift (Apple's programming language) (Apple, 2018). One EPICS student gained experience in setting up an onsite clinic with WiFi to make sure the EMR application could work within the clinic and the iPads could communicate with one another. Not only did EPICS members learn technical skills to be used in their future careers, but students also reported an improvement in their Spanish and an increase in knowledge about the Dominican healthcare

FIGURE 1: Role in clinic



system and culture. Similarly, half of the healthcare students reported an increase in knowledge about the Dominican culture, lifestyle, and healthcare system as one of their top three learning experiences. Not only did American students learn from the Dominican students, but four of the six Dominican students who took the survey noted that one of the benefits of the clinic was being able to practice their English, while three of six students stated their main benefit from the clinic was refining their medical skills with the collaboration of American and Dominican providers.

The survey also included questions about the students' experiences in intercultural and interprofessional relationships. Five out of six EPICS students reported a positive interaction when working with students with a healthcare background. One student, when asked to comment on his or her overall experience with the COPHS and EPICS students, remarked that it "was extremely fulfilling to witness how the efforts of a variety of students can put their knowledge and skills together to make something special happen." Eleven out of thirteen healthcare students reported a positive experience when collaborating with the EPICS team and one stated specifically that the EPICS team is "important for our clinic running smoothly."

While healthcare students, the EPICS team, and Dominican students gained great knowledge while working together, so did the healthcare professionals who helped run the clinic. Half of the providers stated there was a benefit to working in a different scope of practice in a

different culture and stated that their biggest challenge was language barriers between their patients and sometimes their translators. However, the EMR application may have reduced this language barrier by means of prototype through an English-Spanish toggle. All of the providers who took the survey would be interested in using the application in the future. Three out four healthcare providers stated that the application improved the efficiency of the clinic, and one of the providers stated that the EMR improved patient safety by forgoing legibility issues of doctor's handwriting and by allowing the provider to see previous visit history and ascertain a past medical history.

Improving clinic operations was important, but so was seeing the hard work come to life. From one of the EPICS students who attended the trip: "There aren't any words to put in for the experience of the trip. It was incredible and even better on our end to see the work we put in over the semester at work in real time helping people in need. It really gives us a different perspective. It has made me want to go back again next year."

Both healthcare and EPICS student teams appreciated the each other's knowledge base and were able to learn from one another. Seven out of seventeen students from EPICS and future healthcare providers suggested there be more meetings between the two student teams to allow more communication and form better relationships and to improve collaboration on the application prior to the trip. One student conveyed his or her suggestion for improved interactions by stating: "I wish the healthcare students could have had a larger impact when it came to some of the formatting in the app." Another stated, "we could have been helpful when it came to inputting drug names and formatting it the way that most resembles a prescription."

One example of the collaboration between the two groups was a simulation clinic on Butler University's campus before heading to the DR. One EPICS student stated: "Witnessing and collaborating with the students who would actually be using the application was vital. We were able to together identify the most effective and efficient designs for the app, as well as locate bugs

throughout the app that we may not have otherwise noticed.” Four of thirteen healthcare students who attended the simulation said the simulation helped students learn how to use it before traveling to DR and six out of thirteen healthcare students noted there was value in the simulation because it worked out issues beforehand and allowed the EPICS team to add more features to application. More collaboration is necessary because while 10 out of 16 users of the EMR said it was a positive experience, five out of the 16 said there was need for improvements. While the EMR needs improvement, all of the 13 healthcare students who took the survey stated that their overall experience was positive.

Finally, knowledge was gained through this experience but so were friendships.

“The trip felt like a once-in-a-lifetime experience. It was incredible to witness both teams’ work and preparation pay off. Our group of students formed a tight-knit group with relationships that will likely last a lifetime. We were also able to form friendships with people there and share our cultures with one another. I greatly enjoyed the activities outside of the clinic—they provided inspiration on how we can continue to make a difference.”

While the application and learning is important for the students, for healthcare professionals the patient is the top priority, and for engineers the customer is the top priority. To ensure our patients were satisfied and to see how an EMR effects clinic processes we interviewed 95 patients to assess where there is room for improvement with our application and clinic in the future. Figures 2–5 represent how patients responded when asked about the amount of time it took to enter the clinic, register at the clinic, see the physician or healthcare provider, and receive their medications. Responses concerning the amount of time it took to enter the clinic were the most evenly distributed of the four figures, ranging from “very fast” to “normal” amount of time. The amount of time to be registered as well as to see a provider were very similarly distributed, with only a small percentage of patients reporting “too long” of a wait. The amount of time to receive medications followed a similar distribution to

FIGURE 2: Time to Enter Clinic

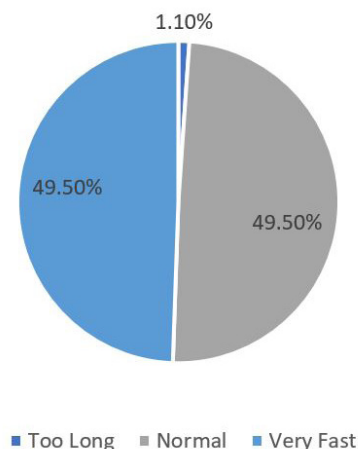


FIGURE 3: Time to Register

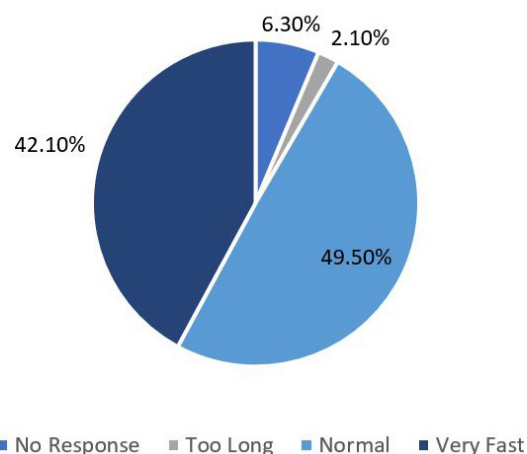


FIGURE 4: Time to See Provider

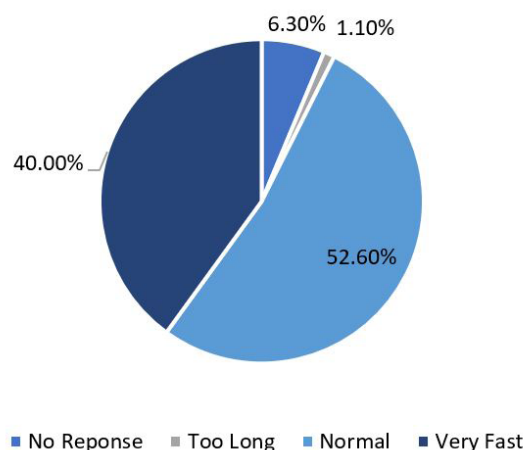
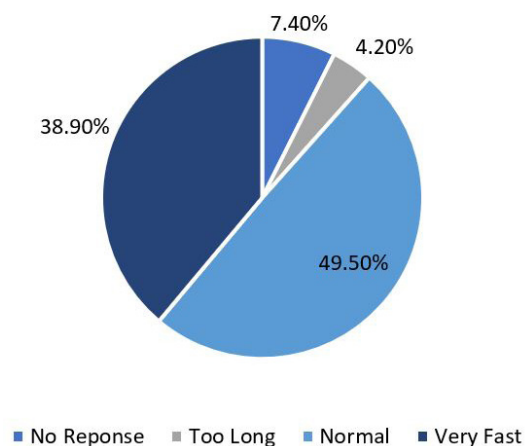


FIGURE 5: Time to Receive Medication



Figures 3 and 4; however, it was the largest report of “too long” a wait. Patients were also asked if they had attended the clinic previously, which 46 out of the 95 patients who completed the survey had. Of the 60 patients who responded to the question about whether this clinic brings their community hope, all answered “yes” and all 95 patients who answered the survey said they would recommend this clinic to their friends and family.

Discussion

The professional world becomes more intertwined each day with professionals obtaining multiple degrees, technology advancing at a rapid pace, and the increased need for multiple professionals to be working together to achieve a common goal. Students with healthcare or computer science backgrounds will work together once they enter their careers, because healthcare is constantly in conjunction with, and reliant on, technology. Learning about other disciplines through collaboration towards a mutual goal helps prepare students of both colleges and disciplines to better communicate with people who have different educational backgrounds.

Beyond communication, other lessons learned through this experience included collaboration and teamwork. This project began through collaboration, as Barnabas Task has been collaborating since 2008 with people from varying cultures to facilitate CHE. Butler University began helping staff and supplying clinics in 2014, and the EPICS team was introduced in 2015 to create the EMR application (Barnabas Task, 2013). Similar to the

mission trip described by Dressel et al. (2017), students reported an increase in their teamwork skills. The application continually evolves as innovative ideas develop from communication and teamwork between the EPICS and healthcare students. To improve both this learning experience and the application, the EPICS and healthcare teams need more collaborative meetings and communication, which have been set up via live simulated clinic days in the United States. The team views the application working in real time and can modify the application before arriving at the clinic. The need for more simulations was reiterated in the survey results: almost half of students wanted an increase in the number of meetings between the two groups prior to the trip. More meetings will allow for the healthcare students to help update the prescribing and diagnostics parts of the application and to provide recommendations for further clinical functions in the prototype application, including drug interaction reporting and other patient safety features.

It is important that the students gained knowledge from this collaboration, but ultimately the goal is to help the patients in the DR. An EMR application is warranted for helping track past medical records; over half of the patients who took the survey reported being seen in the clinic previously. With patients returning each year, there is clearly a need for the clinic, and the clinic is being utilized as routine care for many people. The application allows past medical records to be viewed, to see progression of disease states and to ensure that the patient is receiving the best care possible. The application improves patient safety by allowing allergies to be documented and viewed through their prior visit history. The support for EMRs improving patient safety has been shown in the work of Khalifa (2017), as there were fewer occurrences of medical error. Providers can also access medication histories to track clinical progression. Not only does the application help prevent medication errors, it also improves the processes of the clinic. Patients are quickly registered and triaged and then sent to see a provider, without the hassle of paper charts. Only two of the 95 patient respondents commented that any step of the clinic took too long. Future development and evolution of the application could help further streamline clinic processes and improve patient satisfaction.

Not only is the application evolving, but so is the EMR EPICS project. There has been a growing number

of EPICS students interested in the collaboration with healthcare students. The EMR project continues to attract new and returning Computer Science and Software Engineering (CSSE) students, who find this project intriguing and realize the potential it has for experiential learning. The EMR project has spanned over six consecutive semesters and has currently attracted and engaged 35 CSSE students. The trip teaches students to collaborate with students of different educational backgrounds and helps students discern their future career paths. One of the EPICS students changed his major after exploring his passion for computer programming while working on the EMR project. All participants in the application collaboration group reported some form of educational growth.

Beyond their own education, this experience also exposes students to the education styles of the Dominican Republic. Medical school in the DR takes six years to complete as opposed to the eight years required to achieve a medical degree in the United States. Cultures differ not only in education but also in communication styles and language. Learning to respect the cultures and healthcare systems of other countries will help students become more adaptable and knowledgeable as they embark on their future careers. It is also beneficial to familiarize oneself with other cultures, because many medical professionals are obtaining their degrees abroad, while still wishing to practice in the United States. This trend was voiced by many of the medical students who acted as the group's translators during the clinic in the DR. As of 2006, approximately 25% of physicians practicing in the United States obtained their medical degree abroad, a number that has been increasing since the 1960s (Boulet, Cooper, Seeling, Norcini, & McKinley, 2009). Not only are physicians with different educational backgrounds practicing medicine in the United States, there has also been an increase in the number of foreign-born United States citizens. With almost 13% of the United States' population being born in another country, providers will be encountering patients with a variety of backgrounds (Singer, 2013). It is important for healthcare providers to adapt and be knowledgeable of cultures different from their own. Cultural awareness is the main experience gained from clinics where US and DR students volunteering together.

In the future, it would be beneficial to continue to track patient surveys to ensure that the application keeps improving patient satisfaction and clinic efficiency. However,

it is reassuring to see that a majority of patients did believe that their wait times were acceptable and that the clinic is currently working at an efficient pace. Looking forward, it would also be appropriate to start examining clinical outcomes of patients, as the EMR is able to track them on a yearly basis to see whether medical interventions are making a long-standing impact on patients' disease states. As Kruse et al. assert (2017), EMR systems can improve quality outcomes for patients in the acute setting. Data collected from the DR clinic could be examined to determine whether these same improvements can be repeated. Overall, the collaboration between healthcare students and computer science students has led to the production of a functioning, affordable EMR application prototype to improve patient safety and satisfaction. It has also expanded technical and communication skills for students across Butler's campus and among the DR students that Butler University connects with while in the DR. The goals of this project in the future would be to keep improving the application and eventually provide access to the application to other non-profit organizations to help them serve their patient population.

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Demographics

1. **Is this your first experience with Barnabas Task?**
 - a. No
 - b. Yes
2. **How many times have you worked with Barnabas Task?**
 - a. 1-2 times
 - b. 3-5 times
 - c. 6 or more times
3. **What was your role with the EMR app?**
 - a. Healthcare Student
 - b. Healthcare Provider
 - c. EPICS Team
 - d. Translator (PUCMM or OASIS Student)
 - e. Clinic Organizer
4. **Describe your major.**
 - a. Pharmacy
 - b. Physician Assistant
 - c. Nursing

EPICS Team

5. **Why did you select this project? What was your motivation behind selecting this project?**
6. **Name the top three non-technical learning experiences that you took away from the EMR project.**
7. **Name the top three technical learning experiences that you took away from the EMR project.**
8. **Comment on your overall assessment and grading of your performance throughout this project.**
9. **Did you participate in the trip to the DR?**
 - a. No
 - b. Yes
10. **Comment on your overall trip experience.**
11. **What did you learn from the PUCMM/OASIS students while working in the clinic?**
12. **Comment on the amount of time spent on devotions and reflection.**
13. **Did your faith change or grow? Comment on this.**
14. **Were you interested in going on the trip to the DR?**
15. **What prevented you from going on the trip?**
16. **Comment on your experiences of interacting with the healthcare students.**
17. **What suggestions do you have to improve the way the two teams interacted?**
18. **Did you participate in the EMR simulation in March?**
 - a. No
 - b. Yes
19. **What value did you find in this simulation?**

20. **How have you used the knowledge and skills from this course outside of the classroom?**

Healthcare Students

21. **Why did you decide to participate in this trip?**
22. **Name the top three learning experiences that you took away from this experience.**
23. **Comment on the amount of time spent on devotions and reflections.**
24. **Did your faith change or grow? Comment on this.**
25. **Comment on your experience with the EPICS team (those that went on the trip and those that did not).**
26. **What suggestions do you have to improve the way the two teams interacted?**
27. **Comment on your overall experience in the DR.**
28. **What did you learn from the PUCMM and OASIS students while working in the clinic?**
29. **Comment on your experiences using the EMR app to automate the patient care process in the DR.**
30. **What did you like about the EMR app? What would you improve or change?**
31. **Did you like the text boxes used for diagnosis?**
 - a. No
 - b. Yes
32. **Did you participate in the EMR simulation?**
 - a. No
 - b. Yes
33. **What value did you find in this simulation?**

Healthcare Providers

34. **What is your role and capacity of involvement in the clinic? Comment on your previous involvement with Barnabas Task medical clinics.**
35. **Comment on any benefits and challenges you had from your participation in this clinic.**
36. **Did you utilize the EMR app?**
 - a. No
 - b. Yes
37. **Describe your overall experience and impression of the EMR app. How did you find it useful? How could it be improved?**
38. **How do you think the app affected patient care?**
39. **Would you be interested in using it in the future?**
 - a. No
 - b. Yes

Clinic Organizer

- 40. What is your role and capacity of involvement in the clinic?**
- 41. Comment on any benefits and challenges you had from your participation with this clinic.**
- 42. Did you utilize the EMR app?**
- a. No
 - b. Yes
- 43. Describe your overall experience and impression of the EMR app. How did you find it useful? How could it be improved?**
- 44. Would you be interested in using it in the future?**
- a. No
 - b. Yes

Translators (PUCMM or OASIS students)

- 45. What was your role in the clinic? Comment on any previous experiences with Barnabas Task.**
- 46. Comment on any benefits and challenges you had from your participation in the clinic.**
- 47. What did you learn from the American students?**
- 48. Did you use the EMR app?**
- a. No
 - b. Yes
- 49. Describe your overall experience and impression of the EMR app. How did you find it useful? How could it be improved?**
- 50. Would you be interested in using it in the future?**
- a. No
 - b. Yes



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 challenges* 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 feasibility 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 eMentorship 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 adequate 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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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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Websites

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- SENCER website: <http://sencer.net/>
- SENCER-ISE website: <http://sencer-ise.net/>

APPENDIX A.

DEVELOPING A FRAMEWORK FOR CIVIC ENGAGEMENT PARTNERSHIPS (KEY THEMES FOR IMPLEMENTATION OF CROSS-SECTOR PARTNERSHIPS)

Implementation Approaches	Sources
<ul style="list-style-type: none"> • 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?
<ul style="list-style-type: none"> • 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 	<p>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.).</p> <p>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).</p>
<ul style="list-style-type: none"> • 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.
<p>As part of the selection process, applicants had to</p> <ul style="list-style-type: none"> • 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. 	<p>From RFP for Civic Engagement Partnership Awards Program</p> <p>Note: Applications were distributed between January 23 and February 13, 2013 and were due on March 15, 2013.</p>

APPENDIX B:

FIRST TEN SENCER-ISE PARTNERSHIPS, WITH TITLES AND SUMMARY DESCRIPTIONS

Partnership	Proposed Project Titles/Description
Antioch College/Glen Helen Outdoor Education Center	<p>"Biodiversity, Invasive Species and Forest Restoration: Integrating Civic Engagement in the Classroom and Outdoors"</p> <p>Design curriculum for an introductory Environmental Sciences course around the issue of biodiversity loss following non-native species invasions and also offer civic engagement</p>
Brooklyn College/Gateway National Recreation Area of the National Park Service	<p>"Sentinels of Shoreline Change"</p> <p>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</p>
Cornell University/Sciencenter	<p>"Science from the Start" Engaging Researchers, Undergraduates and a Science Museum to Reach Early Learners and Set the Stage for STEM Learning"</p> <p>Create tools for parents/caregivers to learn the science of cognitive development so that young children have the best learning environments possible</p>
Fordham University/Wildlife Conservation Society	<p>"Project TRUE: Teens Research Urban Ecology"</p> <p>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</p>
Hamilton College/Green Science Policy Institute	<p>"Chemistry and Civic Engagement: The Study of Toxic Chemicals in Everyday Products"</p> <p>Develop research opportunities for undergraduate science students that couple analytical toxicology with public policy</p>
New Mexico EPSCoR/New Mexico Museum of Natural History	<p>"New Mexico Informal Science Current Research Network"</p> <p>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</p>
Paul Smith's College/The Wild Center	<p>"Integrating Climate Science"</p> <p>Engage college students in a new class offering in developing targeted climate science communication to community gatekeepers</p>
Raritan Valley Community College/New Jersey Audubon	<p>"Integrating Citizen Science and Community College Efforts in Assessing Forest Health in New Jersey"</p> <p>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.</p>
Saint Mary's College of California/Lindsay Wildlife Museum	<p>"Facing the Future: Sharing Habitats with Wildlife"</p> <p>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</p>
University of Connecticut/Connecticut Science Center	<p>"Genome Ambassadors"</p> <p>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</p>

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