

Communicating Ocean Sciences to Informal Audiences (COSIA)

Final Evaluation Report

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INTRODUCTION

Communicating Ocean Sciences to Informal Audiences (COSIA) is a National Science Foundation (NSF)-funded project consisting of seven long-term three-way partnerships between the Lawrence Hall of Science (LHS) and an informal science education institution (ISEI) partnered with an institution of higher education (IHE). Together, educators from the ISEI (often aquaria) and the IHE develop and implement a course called *Communicating Ocean Sciences to Informal Audiences*, designed and adapted by the Lawrence Hall of Science. This course introduces both undergraduates and graduate students (usually majors from a range of science disciplines) to learning theory and inquiry-based pedagogy, including assessment. Together with the ISEI educators, the college students then design and implement activities to teach ocean science concepts to visitors on the ISEI “floor”. The long-view goal of the COSIA project is to develop scientists’ communication skills to promote ocean science literacy at all levels, thereby encouraging broad public understanding of science and environmental stewardship.

The COSIA project fits well with the longitudinal commitments of the LHS to ocean science literacy, in terms of curriculum development and professional development. For decades, LHS has offered MARE (Marine Activities, Resources, and Education), a whole-school interdisciplinary ocean science immersion program that provides professional development for teachers, curricular materials, and resources for families. LHS has also been a keystone of the Center for Ocean Sciences Education Excellence—California (COSEE CA), one of twelve existing COSEE centers funded by the NSF Geoscience Directorate, Division of Ocean Sciences. The mission of COSEE CA is to, “spark and nurture collaborations among scientists and educators to advance ocean discovery and make known the vital role of the ocean in our lives.”

As a foundational member of COSEE CA and the central organizing agent for COSIA, LHS brings critical assets from its long history of working with universities, K-12 schools and teachers, ISEI visitors, and ISEI educators. One such asset is the *Communicating Ocean Sciences* (COS) course, initially designed by LHS for the COSEE (Centers for Ocean Science Excellence in Education) California initiative, that sends university students into local K-12 schools. LHS leveraged its work on the COS course, which previously had been offered to college students partnered with K-12 schools, to obtain funding from NSF’s Informal Science Education (ISE) division to bring *Communicating Ocean Sciences* to informal audiences through COSIA. For COSIA, LHS adapted and leveraged the course to serve the larger and more varied public audiences of ISEIs such as aquaria. This course serves as the foundation and backbone for building the research-based partnerships and collaborations that promote ocean science literacy through COSIA. Another asset LHS brings—obvious in the success of MARE and COSEE California—is its long-standing service as an effective hub for facilitating partnerships and collaborations that are functional, relevant, and end in mutually beneficial relationships for institutions and individuals. COSIA is supporting such partnerships with a particular goal in mind, that is, to expand the audience for ocean science literacy.

Currently, there are six COSIA partnerships between ISEIs and IHEs:

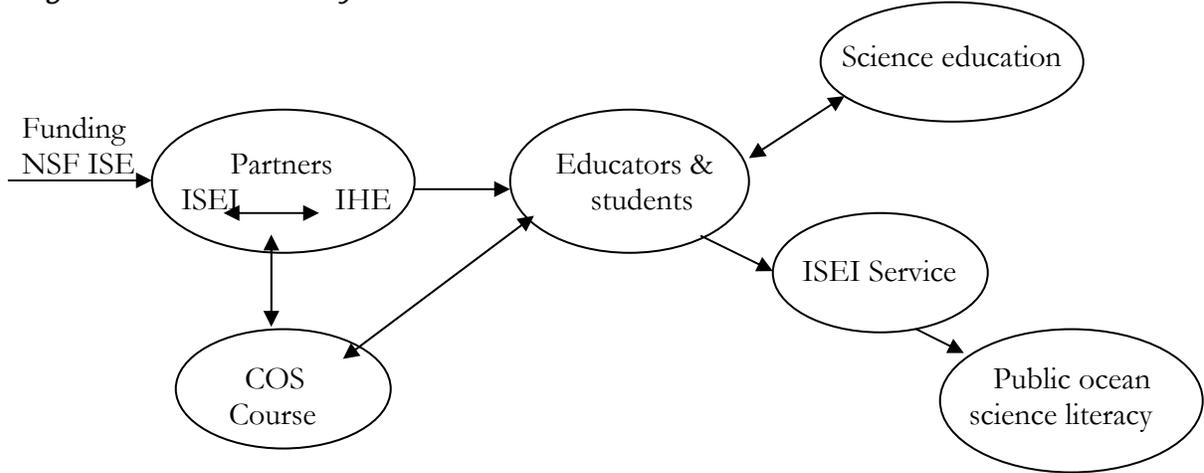
- Hampton University and Virginia Aquarium
- Oregon State University and Hatfield Marine Science Visitors Center
- Rutgers University and Liberty Science Center
- University of California, Berkeley and Lawrence Hall of Science
- University of Southern California and Aquarium of the Pacific
- University of California, San Diego (Scripps Institution of Oceanography) and Birch Aquarium

THEORY OF ACTION

Inverness Research has been the external evaluator for the COSIA project. Inverness Research's studies focus on projects like COSIA as investments, rather than simply services. While the work of this project certainly does involve some direct service outcomes, we look at the project more broadly with an eye toward identifying how returns on the investment are made. This perspective entails understanding how funding dollars invested in a project result in increased capital and capacity. To do this, we work to first articulate and document the Theory of Action of a project, describing the ways in which investments are translated into benefits and intended outcomes. The Theory of Action lays out the mechanisms (i.e., key components and their interactions) by which the investment is translated into multiple kinds of benefits—both for professional and public audiences.

The COSIA Theory of Action depicted in Figure 1 involves using funding from NSF's ISE division to support partner ISEIs and IHEs to implement the COS course. The cornerstone course has brought together the expertise of the ISEIs for reaching informal audiences, with the science research expertise of the IHEs. Therefore, the course serves as the foundation of COSIA but it also serves as a catalyst for the actual work. COSIA has developed partnerships *through* and *for* the teaching of a university course. The course is the tool around which the partners with local capacity and expertise come together. The COS course influences educators and students in both the ISEIs and the IHEs, which ultimately has implications for how science is taught in universities, as well as how science is communicated to the public.

Figure 1: COSIA Theory of Action



OVERVIEW OF THIS REPORT

This report is designed primarily to speak to the funder of this project, the ISE division of NSF; however, we hope that it will also provide helpful information for the designers of other similar initiatives, distilling more general lessons learned about the design and implementation of partnerships like COSIA. Importantly, we would also like this report to inform COSIA leadership and partners, as they move forward with the COSIA Network project. After summarizing our external evaluation activities, this document presents our current findings of COSIA, using research and theory as a way to further explain the salient defining features and to convey what the project has accomplished. We finish this report by presenting Inverness Research’s perspective on COSIA as an investment and a network of partnerships.

Accompanying this external evaluation report are **three COSIA case studies**, which illuminate and portray the work summarized in this report in a more detailed, context-based manner. We recommend that anyone wishing to get a better sense of how these partnerships operate on the ground read these case studies.

EVALUATION

Focus

True to the design we formulated in our proposal, the Inverness Research evaluation studied the COSIA project on two levels: Partnerships and Contributions. The logic underlying these two layers of study is as follows: COSIA creates working and complex partnerships that serve as the “engine” for the development of new resources and programs. These resources and programs in turn make multiple contributions, ranging from increased institutional capacity, to more skilled delivery of programs by college students and ISEI staff,

to benefits for research scientists, to an increased public understanding of ocean science and research. Therefore, the evaluation focused on the ways in which the partnerships functioned, developed new or improved programs and resources, and ultimately added value to the partner institutions.

Activities

This report draws on data collected from the following evaluation activities Inverness Research has engaged in:

- Met with LHS COSIA leadership group at Inverness for a project planning and kick-off meeting, July 2006
- Reviewed COSIA written materials and website, Summer 2006 - present
- Conducted quarterly update and planning meetings with LHS staff, Fall 2006 to present
- Attended COSIA partner check-in meetings with LHS staff by telephone, Fall 2006 and Winter 2007
- Conducted telephone interviews with ten partners and seven college students, Spring and Summer 2007
- Reviewed internal evaluation data, Summer 2007 - present
- Attended workshop for Communicating Ocean Sciences course at LHS, June 2007
- Completed interview summary report, Fall 2007
- Conducted site visit to UCSD Scripps Institute of Oceanography and Birch Aquarium (including interviews and observations of university course and museum floor activity), May 2008
- Attended COS Partners' Meeting and conducted focus group with partner representatives, June 2008
- Conducted interviews with COSIA Leadership, July 2008
- Worked with COSIA leadership to finalize logic model for case study of three sites, Summer 2008
- Conducted site visit to USC and Aquarium of the Pacific (including interviews and observations of university course and museum floor activity), October 2008
- Completed interim evaluation report, November 2008
- Conducted site visit to Hampton University and Virginia Aquarium, April 2009
- Conducted site visit to UCSD, Scripps Institution of Oceanography and Birch Aquarium, May 2009
- Conducted site visit to Rutgers University and Liberty Science Center, April 2010
- Drafted three case study for review, May 2010
- Completed three case study reports, June 2010
- Completed final external evaluation report, June 2010

FINDINGS

The findings described below are organized according to overarching categories and themes that have emerged from our evaluation, across a variety of data sources, including literature and document reviews, observations of and interviews with project participants, and site visits. This section begins by describing the salient design features of COSIA, in order to set the context for a later discussion of the benefits that are experienced by participants. Finally, the findings describe how COSIA is a functioning network.

COSIA DESIGN FEATURES: FOUNDATIONS FOR STRONG PARTNERSHIPS

Partnership research and theory, and our interviews with COSIA participants, all echo one another, in describing how important particular components are for building a sound partnership. We draw upon partnership research and theory to highlight the alignment of the COSIA design features with the hallmarks of “effective” partnership practice. The partnership research and theory support our findings that the intentional design features involved in establishing and maintaining COSIA partnerships facilitate the realization of numerous benefits.

INFRASTRUCTURE AND EXPERIENCE: BUILDING ON EXISTING CAPACITY

This section begins by describing the importance of LHS’ social networks and their prior experience doing this work bringing partners together. It also shows how LHS’ existing infrastructure for doing this kind of partnership (e.g. having a course as a tool for doing the work and having sound leadership capacity) have been critical for making COSIA a unique partnership experience for many of the participants. LHS has the tools and knowledge to catalyze this kind of partnership work. In other words, not only does LHS bring a certain amount of existing capacity to bear on the work, the knowledge and tools they bring produce further improved and increased capacity on the part of the partners.

Social Network and Reputation

In writing about cross-sector partnerships, Kingsley and O’Neil (2004) describe the important role that a social network plays in growing, supporting, and expanding partnerships. Indeed several COSIA partners have described initially becoming involved in the project due to or through personal connections. One COSIA leader recalls how LHS’ social network came into play during the recruitment phase of COSIA:

It was one phone call to someone who I knew I had a good relationship with and they called someone at some place that they had a good relationship with... it is about building those kinds of personal bridges.

Indeed, Scripps is now a COSIA partner (though not a sub-awardee) in large part because a particular individual (who had previously experienced MARE training at LHS) joined the faculty at SIO, having come directly from Rutgers where he taught the COS course. These examples speak to the “ripple effects” of personal connections, and how they can create momentum in partnership projects such as these.

Similarly, another reason for organizations to enter into partnerships and how they function once there is the level of their *embeddedness* (Kingsley & O’Neil, 2004). Embeddedness is an example of an existing infrastructure and established social networks. For example, the Birch Aquarium in San Diego would be expected to have a high level of embeddedness with Scripps, given that Birch Aquarium exists to help disseminate Scripps’s research. As a partner from Birch described it:

We are a little bit unique in some ways because the aquarium is an extension of part of Scripps and UCSD and so while in some other places the partnership can be somewhat estranged at first, in our case the partnership already existed.

Even though some previous embeddedness existed between these partners, it was not as complete as one might imagine—Birch aquarium staff do not take courses at Scripps for professional development, nor have scientists from Scripps previously worked with aquarium staff to develop curricula and programs for aquarium visitors. Additionally, prior to COSIA, Scripps students did not take courses in collaboration with, sponsored by, or located at Birch aquarium.

Other partnerships brought together through COSIA came together with an even lower degree of embeddedness. Some ISEIs and IHEs had never thought to collaborate before, while others may have considered it but didn’t have the means or infrastructure to make it happen. Prior relationships and social networks make it easier for some institutions to come together around the COSIA work.

Even for those partners who hadn’t actually worked with Lawrence Hall of Science previously, the reputation, experience, and capacity for doing this work that LHS has generated over decades was a powerful draw for several of the partners we spoke with. As described above in the project’s Theory of Action, LHS has a strong history and presence in ocean science education (and science education more broadly), a commitment to this kind of work, and an infrastructure in place. As one university scientist partner said:

All of the LHS programs have a history of branching out and having sites, and so they have an infrastructure to do that already—a set way to do it. COSIA came from the Communicating Ocean Science course and these things all build on each other, which I think is really great and a strength.

Another example of the importance of social networks and personal relationships in the COSIA partnership is the support from the leadership at different partner institutions and in turn, their own social networks. These leaders have the ability to either facilitate or constrain the COSIA work; however, to date, most have been remarkably supportive. One aquarium staff member said:

The director of the aquarium is an advocate of this program and she has the ear of the people [at the university] as well. It helps to have her speaking highly of and promoting this program because there is a different level of respect and conversation that happens with the directors, as opposed to with the staff. That helps keep us on the plate and keep the work in the forefront.

A further example of how LHS' existing capacity and reputation for their expertise in this domain, is their ability to strategically recruit partners who also have solid reputations. The partners have also demonstrated a clear commitment to the work of COSIA. The partners are able to resolve tensions and potential conflict because the work is clear and their desire to achieve the goals of the work are in place. One university faculty member contrasted his experience in COSIA with previous partnership efforts they had been involved in:

I have been involved in plenty of projects where there has been conflict to differing degrees, whether it is personality differences, or work ethic, or philosophy of education, or whatever it might be. My experience with this partnership has been that there really hasn't been any conflict and that is probably for a lot of reasons.

The Course as the Tool

A critical piece of LHS' existing infrastructure is the *Communicating Ocean Sciences* course and the workshops LHS conducts to introduce partners to the philosophy of the course, and to share their experiences adapting and offering the course. Importantly, the course itself serves as a concrete tool—an artifact—around which individuals and organizations from the IHEs and ISEIs can do meaningful work together. In other words, the work that must be done is relatively clear—partners must plan and implement the course together. The course is an obvious focal point that holds the partnerships together, and promotes cross-disciplinary discussion and knowledge building between the scientists and the ISEI educators. By design, individual partners must work together to think about how they are going to structure and describe the course, and how they are going to assess students, as well as the course itself. These processes get partners thinking differently about their own worlds (their own communities of practice) and each other's world. Several interviewees alluded to the importance of having an easily accessible and tangible object to ground the work of their partnership. "COSIA can bring to the fold some real meaningful reasons to interact with each other." An aquarium director also explained the importance of the course:

When we partnered with other universities before, we'd have a meeting and come up with great ideas that never went anywhere. But the COSIA course structures these partnerships so that we can actually be successful. Maybe it is because there is money involved, but there was a deliverable, there was an outcome, there was a beginning, a middle, and an end, and I think that was a really good part of it.

A different aquarium partner described how the course provides a structure that all individuals—informal educators, scientists, and students—can easily find themselves and work within:

We would love it at the aquarium to have scientists from the university coming to talk about their science, but I don't think that it would happen if we just said, 'hey scientists, come talk'. With COSLA, there is a course and there are credits and they can fit themselves into that structure.

Another common design feature described by participants is a shared distribution of decision-making and activity among the partners. Each partner must absorb a certain amount of the responsibilities for the partnership, an expectation Kingsley & O'Neil (2004) refer to as “an acceptable distribution of the costs of partnership”. A university faculty described her relationship with her aquarium partner:

My partner and I are joined at the hip and we really rely on each other, because she has the training and she has done it for a long time—informal education, training volunteers, etc. So, it is not like I am teaching the course and she's watching—we teach it together. We designed the class together.

There is evidence of true collaboration and robust partnerships in COSIA, meaning that partners are learning from each other and bringing their respective areas of strengths and expertise to bear, resulting in mutually beneficial relationships.

COSIA PARTNERSHIP BENEFITS

The simple longevity of a partnership is not always indicative of its functionality or success (Pace et al, 2000); benefits aside from simple time spent together should be evident to consider a partnership healthy. Our findings indicate that COSIA partnerships are indeed resulting in a bounty of benefits for individuals, institutions, and even departments. These benefits in turn reflect the greater capacity that is built through COSIA for promoting ocean science education and literacy.

Building Intellectual Capacity: A Foundation in Learning Theory

Prior to discussing more specific benefits, it is worth describing a critical benefit derived by participants across COSIA and that is, a heightened awareness and practical knowledge of learning theory and appropriate pedagogy. This seems obvious and yet it emerges as a surprisingly salient point for informal educators, formal educators, students, and university scientists—with implications for their future work with students and the general public. Participating in *Communicating Ocean Sciences* workshops, planning their courses, and reflecting on their progress all allow partners to establish a common language for thinking deeply about learning and teaching, in ways they probably haven't been prompted to before. Early in the project, when one COSIA leader was asked which partners were more grounded in particular kinds of learning theory, the response was:

Actually, some of the university partners are not grounded in either domain—informal learning theory or classroom learning theory. Some of our partners are not familiar with the seminal papers. So the university partners also seem excited to learn this.

Arguably, there is always a need to improve the teaching of both informal science educators (who are often brought into this profession by mentoring or learning on the job), and university faculty (who are often trained and work primarily as science researchers, not educators, per se). COSIA requires individuals and organizations across the project to reflect on learning theory and its alignment with their own practices and beliefs regarding how people learn. A COSIA staff member observed:

It was very, very evident at the meetings... I would count that amongst the biggest accomplishments, this change in thinking about, 'wow, there is a lot of cool and interesting information and research out there on how people learn and we can learn from that too and then bring that to our institution and improve our programs and activities'. That, to me, is the biggest accomplishment. Partners come away thinking very differently about science and about how to communicate science and about the intricacies of education, both formal and informal.

Benefits to Individuals

Benefits to University Students

In our interviews, the university students participating in COSIA courses described how they had been immersed in learning theory, developed their own lessons for visitors on the aquarium floor, and implemented those lessons with visitor groups in informal settings. The students we talked with reported benefiting from the experience in a number of ways—particularly noting that it provided them with hands-on, direct experience in the field communicating with the general public.

First, we heard from students that they appreciated having developed a deeper understanding of both formal and informal learning theories and the methodology for choreographing inquiry-oriented science activities. They studied the research, which shows that using an inquiry-oriented approach to communicate science is an effective means for teaching and learning. The fact that at some point in time, the COSIA students might be teaching assistants or full-time university professors, speaks volumes about the importance of their learning and practicing sound instructional approaches, such as inquiry-based teaching and learning. Through this, they reported gaining a new perspective on the value of ISEIs as a different domain for providing science education. A university student said:

What I got the most was how to conceptualize learning theory, but putting it into practice was the hard part. I didn't make as much progress in that as I had hoped to. Maybe it takes a long time to develop that... it was pretty eye-opening. I was a pretty blank slate, so I learned a lot about how people learn.

Perhaps most importantly, students told us that through this process, they gained a deeper understanding of and appreciation for the challenge of translating complicated scientific concepts—including their own research and knowledge—into content and activities that are appropriately engaging and challenging for a diverse public audience. Two former COSIA students described the benefits of COSIA, using established scientists as non-examples:

I think the biggest benefit to the students here is that a lot of times they are taught how to become a scientist but lose touch with how to present that science.

I wish that COSIA was a prerequisite for scientists... that professors had to take a teaching class to become a professor, but it is not. There are a lot of professors, they can't teach, because they have become so involved in their field, their level of understanding is very different than a layman's understanding. So they have lost that connection.

Three students reported that their experiences on the floor increased their confidence as communicators of science to a range of audiences in different contexts:

It is more than just making up hypothetical projects—you actually get to design these projects and have interactions with the people. I didn't have that opportunity in any of my other classes... an opportunity to really have a direct impact on people outside of the school. I spend all of my days doing very technical aspects of science and people ask me what I do and I have to stop a second and say, 'how am I going to explain this so they don't just tune me out instantly?' I think the COSIA class gives you really good perspective on how people learn and you realize that everyone learns differently.

Most opportunities to communicate about science don't happen in the classroom—they happen when you don't expect it. It's good to know how to communicate in those different situations.

I often interact with people when I am out at the beach. People see me working and they ask, 'what are you doing with these antennas? We have seen these antennas out on our dunes.' They like to know. It is not my primary responsibility to talk to people, but it is a skill that is important for me to have, because people are always asking me these questions. I am the face of Rutgers when I am out in the field. I certainly want to come across as someone who has a purpose and knows what they are doing. And I would like to attract more attention to the research that we did and do.

This is of particular benefit for university level students in science, as scientists' ability to communicate with the public is increasingly seen as a priority in scientific and policy domains. According to students, the COSIA experience provides them with expanding opportunities for outreach work in the future—opportunities that are gaining increasing recognition for their importance in the professional development of practicing scientists. One student put it this way:

We really need to be able to communicate well why our research is important, and it's not formally trained in the Ph.D. program. We need it to teach in the future, for outreach events, grant proposals, and in order to summarize what we do.

Finally, our interviewees have told us that COSIA students' work with the aquarium staff allows the students to cultivate a network of contacts and resources, focused on the practical application of ocean sciences research and content. An aquarium staff member said:

At the Aquarium, [the students] can make good connections with researchers who need to add an education component and have access to new funding, new ideas, and extra help.

Just from the point of view of exposure... there is more interaction, there are more opportunities for the students.

These are contacts and resources the students can maintain for the duration of their careers, should they choose to do so, ever-widening the sphere of influence of the COSIA experience.

Benefits to Educators

Our interviews with the individuals who are engaged in planning and offering the COSIA courses reveal a variety of benefits to the educators as well.

Informal Science Education Institution Educators

Aquaria educators, like the COSIA students, learned more about how to offer engaging activities and rigorous content for learners from a wide range of ages. COSIA participants and partners must learn appropriate pedagogy for pre-schoolers, elementary students, secondary students, as well as college level and adults, including parents accompanying children on an aquarium visit. ISEI educators find an important venue for their work and a shifting sense of the importance of their work and expertise. One aquarium director said:

Over the past 2 ½ years I have seen a very enlightened, interesting, and significant shift in the way in which informal educators at these institutions think about knowing and learning and consequently, how to engage the public in understanding science. This is significant. These institutions have grown up historically as houses of artifacts and factual information, and/or as sources of entertainment, but now they can say 'look, we have really found a way to promote a true deeper component of science learning'.

University Scientist Educators

The university scientist COSIA partners we interviewed revealed a number of unanticipated benefits to themselves as science researchers and educators, and to their own research.

First, several scientists from the IHEs described being introduced to and gaining a deeper appreciation for a different paradigm of education theory and practice—one based in the informal learning realm.

For me, one of the really big advantages of being involved is that it's given me a much better understanding in informal learning theory. My formal background is in science. So I don't have a formal background in education. I didn't take any education courses in college or after college. Going through the course readings has helped me a lot in terms of learning theory... It's been a little tricky at times to practice what I preach as I am learning it along the way. My exposure to the courses is making me a better instructor.

As a scientist, we're not trained as teachers. There are a lot of techniques that I learned that were helpful. Thinking about audience while preparing presentations will change my teaching. I modified things I was teaching in other classes in real time.

Many of us have worked in informal but we weren't really schooled in informal. We were excited to find out what was going on in the [research about] informal education. That was a nice surprise... We probably need to tap into that [informal research] community a little more than we have.

Importantly, COSIA prompts university scientists to discuss appropriate pedagogy in a way that prepares future scientist faculty members to be better science educators:

The message would really be, we are having a significant impact on the way future scientists and current scientists think about teaching and learning and they are actually changing their courses at their institutions such that they are more in line with current learning theory and we certainly anticipate that there will be greater learning gains based upon those changes in practice and don't you think it would be great if we could get these future professors long before they become professors, because we know we all become institutionalized ourselves and set in our ways, and it is much easier to change, if we do it early on.

University scientists have said in interviews that partnering with local ISEIs has provided them with an important outlet for communicating their research to the public, and testing and honing their communication and outreach skills. With outreach being a requirement for recent research grants, this is a valuable contribution of COSIA, in that it contributes to the scientists' ability to garner additional grant funding. When a university scientist and program director was asked to describe the benefits of COSIA, she responded:

Broader impact-outreach. Even if you are going to be involved with research or some other kind of environmental career, it is appreciated that outreach is going to become an important part of it. Everybody has to be comfortable with the fact that outreach is being done or they will have to participate with somebody that is doing some kind of outreach component, which is important. So, to me, COSIA represents a rather unique resource on campus and something that is not central to our goal, but is indeed an important resource for our students. It is an important resource to us because not only is it unique, it is, in my view, stellar.

Similarly, a COSIA leader reported:

COSIA is increasing the acceptance of education as a scholarly discipline among scientists and that has been an uphill battle for a long time and I think there has been significant headway and I think that is probably one of the biggest and hopefully long-term benefits from this.

Another university scientist described his increasing awareness of scientists doing outreach education and the value of it for his students:

Our faculty recognizes the value to students of having connections outside the university. I think the faculty is realizing there's value in outreach education for graduate students, specifically within the biology and marine biology section.

Meanwhile, a university scientist asked to describe the benefits of COSIA said:

There has been historically a separation between education and scientific research and I see this course as a great bridge—one that prepares future scientists and educators with a connection before they hit the streets, if you will. I think that is one of the crucial things with this course. And when we are talking about broader impact, if you are putting these students that take the course into these informal science institutes, the general public is getting a more enriched experience as well—and a very current experience. I think that is a huge, huge area that needs to be addressed and is addressed with a course like this.

The more unexpected benefits scientists reported included: the scientists' efforts with students furthers their research in several ways, they benefit from their work having broader impacts on the community, and they have a pre-existing foundation or infrastructure in place to help them do education and outreach work.

One scientist said that being able to communicate well with diverse audiences allows scientists to get support for their research and to continue exploring.

Scientists do need to communicate. What is their interest? They are interested in the things that help their research. They are very much interested in how do they get funding, how do they find students and how do they continue exploring and how do they continue learning? We also want to get students and so how do we increase that pool of students... we are concerned about the pipeline.

When asked why having students in the pipeline helps scientists, this scientist explained that through courses like COSIA and internships, students help with pilot research studies. Students in classes that are funded through education programs allow scientists to have access to more inexpensive manpower to run their labs and projects and perhaps more importantly, to test technologies that might be considered too high risk to be funded by the science community:

It helps us get our research done. We are people-limited often. We could never have done some of these things without the undergraduates. We were looking at [our experiment] and said, 'there is no way we are going to do this by ourselves. Nobody is going to fund it as research—it is too risky for research'. But it got funded immediately for education. Alumni gave us the money, because they wanted to have research experiences available to the undergraduates. They thought that was great... because the students were having research experiences. I think that is a very important piece of it—getting those students involved.

A scientist pointed out that bringing in an education component provides even more funding opportunities for ocean science research—through education funding:

What we see now is that the education starts to feed back on the research and that is closing that loop and that is very important for continuing this because there is not enough money in oceanography, but when we have education people funding us to do ocean science research with undergraduates, that then feeds back and they can test technologies that the research community is not ready to test... now we are getting other science opportunities.

Traditionally, there has been such a wide separation between professional university science and education that many scientists just don't know how to go about becoming involved in education. It is daunting and they don't have the time to figure it out. Two scientists described how COSIA helps reduce the amount of time and energy required for scientists to become involved in education and outreach:

Scientists care about their research and they care about education on many levels, but they are overtaxed with their time and so there is a huge activation energy to get anything extra done. So anything that you can do to help relieve the burden and make it easy for scientists to interact with students, and easy for them to do these education things with schools, scientists are usually willing to do it—whether there is a criteria to it or not—it is just that extra activation energy required. They are so busy.

The second scientist explained:

I know why I am involved and why research scientists are involved is because COSIA is structured in a way that is very easy for us to participate.

Finally and importantly, partner educators from *both* the IHEs and the ISEIs reported making personal connections and developing relationships that are and will continue to be valuable on many levels. In several cases, these educators have worked in relatively close geographic and conceptual proximity for years but previously, had not experienced each other's work, much less collaborated with one another. Primarily, these connections among educators have broadened the audience for their respective work and will likely lead to future opportunities for these educators to work together. An aquarium staff member said:

We have always been neighbors, so to speak, and we have collaborated on different projects, but I think that now, there is a greater level of confidence in the other partner, to be able to work together to make something happen and I hope that is something that leads to other kinds of outcomes in future projects down the line.

An aquarium director described the productive professional and personal relationship that has been established through COSIA:

I think the Aquarium staff and myself would all be really interested in working together again closely. There is a good productive partnership here, in terms of our learning styles. In the future, I may be working with them to develop a "deep seed" related to a different project, something that was already on the books. But now that we've worked together, we can approach that project a lot sooner.

Benefits to Institutions

As noted in Oliver (1990), "it is far more common for partnership studies to try and explain the reasons for the formation and structure of relationships rather than the added value to the partners themselves." Our interviews with partner educators are a start to documenting several positive impacts of the COSIA work on the affiliated institutions—the IHEs and the

ISEIs. COSIA partnerships can create value for institutions through contributions to human capital and organizational development. COSIA allows ISEIs and IHEs to further their shared goals, while respecting their individual missions and identities.

Benefits to Informal Science Education Institutions (ISEIs)

For ISEIs, COSIA provides opportunities to translate their mission into additional operating goals. First, the COSIA students on the floor provide more capacity to reach public visitors. Said one aquarium director:

It helps us because the aquarium is limited simply by finances, by the number of people that we can have out on the floor and the number of people we can get to do this. So this partnership is very rich because it helps the aquarium's outreach mission and it helps the educators train.

COSIA allows ISEIs to bring new programs to their public visitors, including their regular members. An aquarium staff educator said:

One of the things that has benefited the aquarium is that when the students have to actually do their activities with the public—effectively, those are extra public programs for us. They bring usually one very interesting project to showcase and that is a great benefit to us, especially our regular members get very excited about seeing something new and different.

An aquarium director added:

I can proudly say I am meeting my mission with this work, in a very different way than we have done before.

Interviewees from other ISEIs involved also reported that the presence and involvement of the scientists from the universities added another, particularly relevant dimension to the ISEI's work with the public. Participants commented that information and ideas about the content is deepened when scientists are there to interact directly with the public. One ISEI CEO feels strongly that his institution should showcase cutting-edge science by providing access to research scientists. Not only does COSIA fit this agenda, it is a perfectly well suited and already-established avenue to further the ISEI's mission. Overall, COSIA allows the ISEI to more effectively serve the public—there is a direct contribution to the public's ocean science literacy.

The status and profile of the ISEIs was reportedly heightened through their work with the university scientists—they developed enhanced social and political capital. Scientists reported developing new respect and admiration for the work of the ISEIs (aquaria) and for their expertise in an area (informal education) that is highly evolved in its own right.

A university scientist said:

One thing that it has enabled us to do is strengthen the relationship with the Aquarium as an outreach place for us. There are certainly researchers who have used the Aquarium but there are many who haven't. As word of the course gets around, it will help raise the profile of the Aquarium. There is a salience behind the work that they do.

The work and expertise of the ISEI staff was made more visible and relevant in the eyes of their colleagues and in their perceptions of themselves, as well. One aquarium staff member said:

Integrating into the [university] community in a way in which we have never done before is huge and it allows us to demonstrate our professional expertise and prowess. It is an unusual avenue for us to be able to get into, and to say, 'we can be professors and we can teach courses at this higher content academic level too. It is not always first grade we work with'. That is important. Professionally, as an informal science facility, we are recognized differently in our peers' eyes.

An unanticipated benefit of COSIA that aquaria staff reported to us is the ISEIs' additional capacity to provide professional development for their own staff. Interviewees have reported that the contents of the COSIA course (e.g. the Learning Cycle) and the partnership program are incredibly applicable for their work at the ISEI. Some aquaria have already offered either shortened versions of the entire COSIA course sequence or have shared elements of the course (such as the Learning Cycle) with ISEI staff educators.

Benefits to Institutions of Higher Education (IHEs)

Increased Inter-Departmental Collaboration

Through COSIA, some university scientists have become knowledgeable and practiced in learning theory (both informal and formal) to such an extent that they have been invited to participate in inter-departmental work that in turn increases the potential for additional funding opportunities. For example, one COSIA partnership was incorporated into two GK-12 projects at the university, due to their experience with the COSIA pedagogy, which was more aligned with inquiry-based pedagogy and the learning cycle than what the university's school of education was going to offer. In fact, the GK-12 grant project managers declined working with the university's graduate school of education (GSE), in favor of working with this COSIA partnership because they believed their teaching style (which involved inquiry-based activities that exposed participants to the learning cycle and appropriate pedagogy) was more appropriate than what the GSE had proposed (which involved lectures about pedagogy for fellows and teachers).

Participation in COSIA has also created increased opportunities for departments such as Earth Science, Environmental Systems, Media, etc. to collaborate on providing new course opportunities and inter-disciplinary programs for students.

Additional Course Offerings

Our interviewees reported that COSIA has allowed IHEs to expand their course offerings, including providing education courses where there were none previously. Two university faculty members described the COSIA course at their institution:

It is a unique resource—there is nothing else being done like it, on campus, for sure. [Our university] is not a school for training teachers per se. So a course like this does have an important place in our curriculum because there are students—science students, biology students, marine science students—who are interested in trying out something that would have to do with education or outreach.

For the first time, the course had a waiting list and we weren't able to accommodate all the students who wanted to participate.

Some universities have completed making the *Communicating Ocean Sciences* course a permanent course in their catalog, while others are in the process of doing so. In some cases, the process can be a challenge, requiring faculty sponsor approval, departmental approval, and committee approval.

It could be argued that the difficulty of institutionalizing the COS course and making it a permanent formal offering at some universities speaks to the fact that the scientific field feels no urgency to address this need within current preparation programs for future scientists, even though there will be future scientists who will not be prepared to effectively communicate with the public—through schools, media, and informal contexts. However, some university scientists are not so pessimistic and feel progress is being made:

We invited the associate director of undergraduate programs to come sit in on one of our classes and she saw our students doing their activities on the floor and I think that was a good thing for her to see. Some of her students were in the class too. I think she has a better understanding of what the class is about now and got involved in this conversation of how can we take it to the next step. So we are slowly getting there... we are moving in that direction.

This is evidence that COSIA is resulting in an increased awareness and appreciation of the importance of sound pedagogy in university science.

Benefits to Both Partner Institutions

Additional funding for new programs and projects

Interviewees from both IHEs and ISEIs reported that through COSIA, they have increased their capacity to leverage COSIA and develop new programs for students, schools, and the public, related to the COSIA course objectives and content. One university faculty member said:

COSIA sparked a lot of these other partnerships. Instead of looking at our grant programs as being independent entities, we have started trying to look at how we can connect them.

Particular sites have reported new opportunities to: be a part of the COSIA Network, be part of NSF GK12 projects, work with 4-H, work in Puerto Rico, and receive funding from sources as varied as NOAA (National Oceanic and Atmospheric Administration), NASA (National Space and Aeronautics Administration), and the Department of Homeland Security (DHS), and private foundations, such the Geraldine R. Dodge Foundation and the Gordon and Betty Moore Foundation.

One faculty member said:

I have been talking to even more people about leveraging what we are doing for COSIA. We are doing an international program in Puerto Rico where we've got teachers from the US and other countries coming together. This is not just about one program, and it is not even about one funding source, it is the idea of tying opportunities together with people who have the interest and the commitment to do that.

Institutionalization of the work

An important outcome of participation in COSIA is the ability of partners in IHEs and ISEIs to institutionalize the COSIA work to such an extent that there is increased capacity throughout the organization to continue to offer the course and not be dependent on the staff that was initially involved in the partnership. Three institutions (a university and two aquaria) have lost their initial individual COSIA leads (PIs) to other projects or other sites but COSIA lives on, after responsibility was thoughtfully handed from one educator to another, thereby avoiding the “Tragedy of Turnover” that often characterizes partnership work (Kingsley & O’Neil, 2004). One university scientist and program director described what happened when their original PI left:

There is no change in what we are doing, but there is a change in how the campus perceives what we are doing. This was an important step and it was a timely step and it was an overdue step and it was because our [administrator] decided that COSIA was a priority.

Increased capacity to partner in the future

The skill sets associated with partnership itself are quite valuable and under-rated (Kingsley & O’Neil, 2004). Through their participation in COSIA, both partner organizations have increased knowledge and capacity to partner in the future. One member of COSIA leadership observed:

In the beginning, they were both of a mind that ‘I don’t know about the other field at all’ and now they wouldn’t say that anymore. They respect each other’s expertise greatly and they have a better understanding of what that expertise is and how they can use it.

Indeed, several of the partnerships continue to work together through, and contribute to, the COSIA Network.

COSIA: FUNCTIONING AS A NETWORK

A network can create a reciprocal and symbiotic relationship: the stronger the partners are, the more they can contribute to the network, and the stronger the network is, the more it can, in turn, contribute to each partner. As the LHS staff planned to deepen and broaden their COSIA work, and as they situated the knowledge gained through COSIA within the broader field, they carefully considered COSIA evolving into a sustainable network. In an

effort to develop a sustainable network, the partners as well as LHS continued to maintain the existing strong partnerships and made way for new partnerships.

LHS: The Center of a Network

Associated with COSIA institutions' increased capacity to do the work of COSIA and to partner with one another, is the increasing awareness across participants regarding the value of Lawrence Hall of Science serving as a central “node” of expertise that provides support to partnerships, far beyond simply initiating them. LHS has been organized, responsive, and flexible in its efforts to foster and support the COSIA partnerships. Having a core curriculum or course that is grounded in a long history of research and development work and that can actually be adopted or adapted as a university course for credit, is a significant and noteworthy strategy. Having the administrative and organizational support for implementing the COSIA course in a range of contexts is challenging, and LHS has met that challenge. Through their centralized capacity, LHS is shepherding the mission of COSIA while still being flexible to different local contexts. One aquarium director described the responsiveness of LHS:

With our situation—where things are a little different and don't quite work as well—instead of being rigid or not responsive, LHS is really, really flexible. That is important, because when you were awarded a grant or even when NSF initially put together a program, you have an idea of what it's going to look like. But the reality of the people and the students and the situation, might be different. And to be responsive to that—to be flexible—is the key. We would probably not have been able to continue to be successful if LHS took the rigid approach.

One LHS leader described their approach to supporting COSIA partners as:

We really want to think critically about how to engage the public or college students so we are very open and willing to try new things and accept other ways of seeing the world and seeing where it goes.

Characteristics of a Healthy Network

At the end of the COSIA grant period, the project is functioning as a network and will continue to do so in an official capacity as the COSIA Network. While Inverness will be exploring and documenting the extent to which COSIA Network shares the characteristics of a healthy network that we have identified so far (Appendix A), it is important to note that even in COSIA, the partners shared several features that were indicative of a supportive network. Partners shared a vision for the purpose and goals of the COSIA work and the nucleus of the network was easily identifiable. Partners also developed their visions for future work together and expansion and development of their current work. COSIA partners shared real work and made concrete contributions to each. At each meeting, partners themselves were responsible for some portion of the proceedings—often describing something they had implemented for the benefit of the other COSIA partners—and they learned

from one another. This has been especially evident when sites with different contexts and pressures have shared their experiences and exposed the natural variation among partners. COSIA sites have become increasingly skilled in drawing lessons learned from sites that are inherently different than theirs—and again, LHS has been appropriately flexible by not requiring wholesale fidelity to their model. We have observed high internal coherency and connections—some COSIA sites have begun to collaborate directly with each other, forming smaller sub-networks, to do their work more effectively. The project has created multiple opportunities for partners to interact and participate in a network with each other: they have several face-to-face meetings (at least one per year), and currently, they are establishing Google groups and Ning groups to facilitate even more frequent interaction. As COSIA Network continues, it will be especially relevant to watch how new partners are brought into the network, how the network is recognized by the broader field, and how the network governs itself.

CONCLUSIONS AND SUMMARY STATEMENTS

Our Perspective on the COSIA Investment

Our own perspective on and evaluation of COSIA is one that is responsible to the investment. Rather than viewing the initial NSF investment as just an expenditure for COSIA services, we view the investment as having been an opportunity to build capital for the organizations involved in COSIA, and to create opportunities and fuel for future valuable work.

We see the NSF investment in COSIA as having played out in the following way:

- 1) National Science Foundation invested money in COSIA
- 2) The funding initially helped LHS develop products and services (in the form of the *Communicating Ocean Sciences* course and COSIA instructors' manual, partnership manual, partner meetings, and orientation workshops)
- 3) LHS recruited partnerships to form and work with these products (the course served as a concrete focus for partnerships' meaningful work)
- 4) Through the work of the partnership activity, the investment in turn developed capital—human, political, and economic (knowledge was produced about how to refine and adapt courses, how to work together in partnership, how to expand on partnership work, and how to serve as a localized node of expertise).
- 5) Together, the COSIA are an extraordinary structure with the potential to further leverage the capacities developed through the COSIA products, services, and partnership activity.

In other words, NSF provided the funds for LHS to work with partners to do work that was valuable to the institutions, improved capital, and ultimately fueled future work. There is no question that the investment made in the COSIA project yielded important benefits, including direct tangible benefits to informal educators, scientists, students, and institutions. These benefits include the creation of what we call “working assets”. Students reported having gained a deeper understanding of both formal and informal learning theory, as a result of their participation in COSIA. They also communicated the value of the connections and relationships they cultivated through the COSIA experience, in terms of being able to communicate science to a wider variety of audiences. Our data also indicate that the cycle of the COSIA course (the planning, implementing, and reflection) as well as the collaboration itself was valuable to the educators and the students involved.

Moving Forward

Our evaluation supports the proposition that participation in COSIA has contributed to the creation of strong partnerships with the potential to leverage their work for additional funding and project activity. We have evidence that this project was successful and that the specific local sites involved have generated valuable knowledge about the key components of strong partnerships. Importantly, there is a core group at LHS that knows how to provide centralized support and has experience as the center of a network. COSIA developed an infrastructure to facilitate communication and collaboration among local sites. Finally, the work has resulted in concrete resources—tools, guides, and courses—that provide a foundation for and bolster this partnership work. In other words, the COSIA partners began to function as a network before this project was completed.

As partners became smarter about their work in COSIA, they identified doors that the project has opened for them and several opportunities for leveraging their COSIA experience into future work. One aquarium director said:

The CEO is saying that we need college scientists to be involved in the aquarium and more or less, have COSLA run 365 days a year so we always have scientists to work on the floor. It would be great if we could also offer the COSLA course as a precursor to being able to come to the aquarium to do that. Our public gets the benefit of having that real science and that interface and we could be teaching the course as well.

A different aquarium director reported:

I think it is a perfect timing to consider expansion. We are really trying to get 5 steps ahead of the game and really strategically plan long term. The aquarium is in a big growth spurt—physically we may not grow in space, because we just don't have it—but how can we grow in other ways? How do we extend our outreach? COSLA is one way that we are going to do it. I think this is a very timely and beneficial investment and in 5 years, if it moves into something else, great.

With these new opportunities come new questions that could be best addressed by the network. One university faculty member questioned how they would meet the needs of new and expanded audiences:

We were also contacted by folks who are staff or technicians in different areas, or resource staff, who were also interested in taking the COSLA course. They asked 'can we sit in and audit or is there some other way we can take it?' I put them on hold for now but hopefully, we are going to be able to figure out some way to ultimately develop an experience for them, maybe some kind of condensed version of the course. That leads to this other challenge—what would that be? How do we meet the needs of these other audiences and how would we go about doing that, where would the resources come for that and how would that be structured?

A former COSIA staff member articulated some of the questions that face COSIA as it moves forward as a network:

This is something that we have created, but we have put it out there and told people, ‘we want you to modify it, we want you to make it happen in some way and keep us posted’, we are really interested in that. What does that look like, how do you disseminate it, how do you create professional development for it? I do see that as a challenge for COSIA moving ahead.

Experienced COSIA partners were encouraged to develop their leadership capacity and some have. Partners have then become hubs to disseminate COSIA—to serve as nodes of expertise for expanded COSIA partnerships. A COSIA leader described a why this strategy makes sense:

If I talk to them and I say, ‘hey, I really need some help here, and this is something that I think you would be really good at, and are you interested?’... it makes me think about when I have been contacted in that regard before, I feel responsible to do it, and my collaborators here on this project are so wonderful that I want to provide more of a venue for them to really become a part of this.

Being attentive to each site’s achievements and skills has honored the work and expertise of the COSIA partners. We suggest that through COSIA Network, the partners continue to improve the resources and tools—refine and disseminate handbooks and guides—while encouraging local expertise. The tools and resources will work to support local, centralized, relevant expertise.

The COSIA project has generated valuable knowledge and resources that are useful for understanding and supporting strong partnerships in this field. We believe that there is a strong future potential for sharing knowledge through the COSIA Network, and that other organizations interested in similar partnership activity should look to COSIA for important lessons in structuring and maintaining effective partnerships and a healthy network.

Appendix A:

Characteristics of a Healthy Network

(a work in progress)

- 1) A shared vision of the identity, purpose, and work of the network**
 - Good progress on creating a shared vision of the network amongst current members and partners
 - Good progress on creating a core group of institutions to provide a nucleus for the growth of the network
 - Vision for the expansion and further development of the network is emerging

- 2) Support for real work and concrete contributions**
 - Very strong start-up in terms of exhibits, forums, programs, and web material
 - Design and implementation of meetings, courses, and professional development workshops
 - Good start-up on prototypes, models, or pilots
 - Early production and publication of research and evaluation studies, surveys, and guides

- 3) Internal connections and coherency**
 - Working groups or partnerships are increasingly well-defined and making progress
 - Good cross-institutional collaborations within the working groups or partnerships
 - Beginnings of cross-partnership or cross-strand collaborations and contributions
 - Beginnings of larger sub-networks

- 4) Mechanisms for drawing upon and contributing to participating members**
 - Respecting the differences in institutions and their varying strengths and perspectives
 - Taking advantage of natural variation to test and refine models and approaches
 - Need to go beyond production and dissemination approach

- 5) Multiple opportunities for participation and interaction with the network**
 - Multiple opportunities generated for learning about the domain of the network
 - A few early and illuminative examples of including new institutions and people
 - Networks of existing partners invited to participate

- 6) Recognized and valued by the broader field**
 - Good progress on making broader contacts in the domain
 - External perceptions of the network are positive
 - Initial interest in participation and interaction

- 7) Development of network governance and administration**
 - Very good collaboration amongst core partners
 - Administrative team very strong with complementary skills and perspectives
 - Good ability to identify critical issues, problems, and emerging needs
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