Communicating Ocean Sciences to Informal Audiences (COSIA)

Interim 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 prepare and implement a course designed and adapted by the Lawrence Hall of Science. This course introduces college students (usually science majors) to inquiry-based pedagogy and learning theory. 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 ocean science literacy at all levels and to encourage 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. For nearly five years, LHS has 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 CA 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 working in K-12 schools, to obtain funding from NSF's Informal Science Education (ISE) division to bring COS 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 CA – is its long-standing service as an effective hub for facilitating partnerships and collaborations that are functional, relevant, and end in win-win situations 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 seven 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
- Hawaii Community College and the MELE Program

THEORY OF ACTION

Inverness Research is 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 a project does involve service outcomes, we look at a 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 explicate the Theory of Action of a project, describing 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 brings 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 is creating 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.
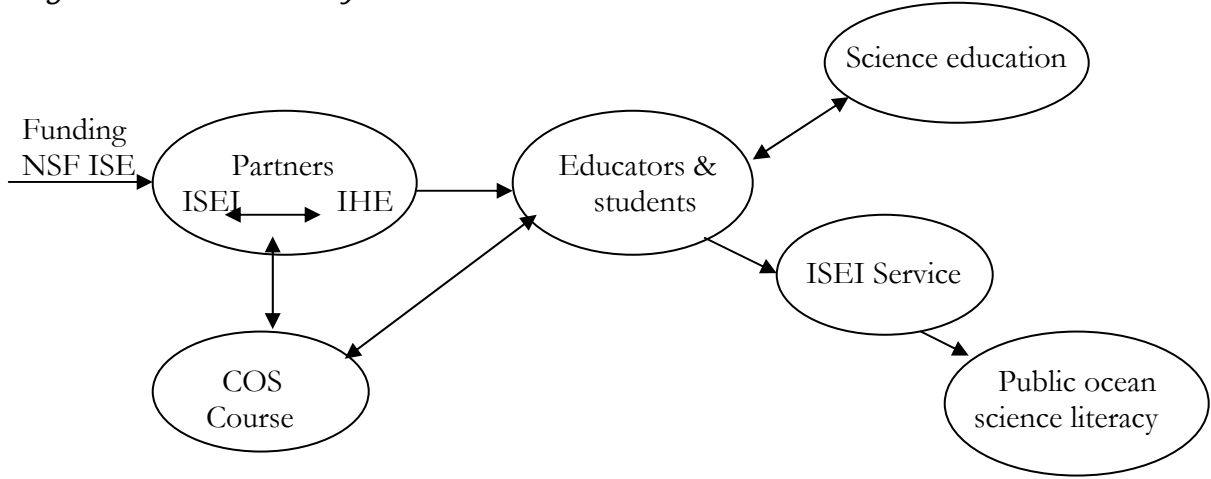
Figure 1: COSIA Theory of Action

Figure 2, which was adapted from the original COSIA proposal to NSF, provides estimates of the nature and number of individuals potentially served by COSIA. Actual numbers will be reported in our final report.

Figure 2: Potential Reach of COSIA

	Families/other public audiences	**ISEI Education Staff**	**IHE Faculty and Students**
Individuals served through COSIA project over a three-year period	25 children/adults x 12 pairs of college students x 6 teaching sessions x 7 ISEIs = 12,600 children/adults per year *(37,800 ISEI visitors over 3 years)*	1-5 staff x 7 institutions = 7-35 staff per year *(21-105 ISEI staff over 3 years)*	24 students x 7 colleges = 168 students per year; 1-2 faculty x 7 colleges = 7-14 faculty per year *(504 students and 21-42 faculty over 3 years)*

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 COSIA, as well as its potential future as a network. After summarizing our evaluation activities to date, 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. Following our findings, we present Inverness Research's perspective on COSIA as an investment and a network of partnerships.

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 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 conducted to date:

- 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

FINDINGS

The findings described below are organized according to overarching categories and themes that have emerged from our study thus far, across a variety of data sources, including literature and document reviews, and observations of and interviews with project participants. The 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 provide a glimpse of how COSIA is, in and of itself, an emerging 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 for bringing partners together to begin with. 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 and expanding partnerships. Indeed several COSIA partners have described initially becoming involved in the project due to personal connections. One COSIA leader at LHS recalls how the 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 and I feel like it is about building those kinds of personal bridges." COSIA is now at the Scripps Institute of Oceanography (SIO) 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.

Another reason for why organizations enter into partnerships and how they function once there is the level of their *embeddedness* (Kingsley & O'Neil, 2004). Embeddedness is an example of existing infrastructure and social networks. For example, the Birch Aquarium in San Diego would be expected to have a high level of embeddedness with SIO, given that Birch Aquarium exists to help disseminate SIO'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.*

Surprisingly, in reality, Birch aquarium staff do not take courses at SIO for professional development, nor have scientists from SIO previously worked with aquarium staff to develop curricula and programs for aquarium visitors. Additionally, prior to COSIA, SIO students did not take courses in collaboration with, sponsored by, or located at Birch Aquaria. 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 track record and 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 for the work of the leadership at the different partner institutions and in turn, their social networks. These leaders have the ability to either facilitate or constrain the COSIA work. 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 doing this work well comes into play is their ability to strategically recruit partners who also have solid reputations. 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:

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. Importantly, the course 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. The course 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 assess students, and how they are going to structure and describe the course. These processes get partners thinking differently about their own worlds and each other's world. Several interviewees alluded to the importance of having a concrete and tangible object to ground and focus the work. "COSIA can bring to the fold some real meaningful reasons to interact with each other." One aquarium director 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 structured those partnerships
so that we could 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 so that I think was a really good part of it.

A different aquarium partner described how the course provides a structure that individuals can easily 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 COSIA, there is a course and there are credits and they can fit themselves
into that structure.

Another common design feature described by participants interviewed thus far is a shared distribution of decision-making and work among the partners. Each partner must absorb an 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 partnership, meaning that partners are learning from each other, bringing their respective areas of strengths and expertise to bear, and true collaborations are resulting in most of the seven cases.

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 time spent together should be evident. Our findings indicate that the COSIA partnerships are resulting in a bounty of benefits and win-win situations that are individual, institutional, and cross-departmental. These benefits in turn reflect greater capacities built at respective institutions 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 crucial benefit derived by participants across COSIA – 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 participants across the project – informal educators, formal educators, students, and scientists – with implications for their work with students and the general public. Participating in COS workshops, planning their courses, and reflecting on 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 upon teaching – on behalf of 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 has prompted individuals and organizations across the project to reflect on learning theory and 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 then implemented those lessons with visitor groups in informal settings. The students we talked with reported benefiting from the experience in a number of ways.

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. Through this, they reported gaining a new perspective on the value of ISEIs as a different domain for providing science education. 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. 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 public audience. Another student described the benefits of COSIA:

> *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.*

Their experiences on the floor reportedly increased their confidence as communicators of science. 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 interview results tell 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. Aquaria educators, like the COSIA students, learned more about how to offer engaging activities and rigorous content for a wide range of ages. They 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. Faculty from the IHEs (i.e. university scientists) 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. One university scientist said:

> *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 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.*

Another university scientist said:
> *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.*

According to a university scientist:
> *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.*

Most 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. Firstly, 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. 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 learning'.*

Importantly, the status of 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 faculty 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 university scientist was incorporated into a GK-12 project, due to his experience with the COSIA pedagogy, which was more aligned the inquiry-based pedagogy and the learning cycle. 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 scientist because they believed his 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. One university scientist described increased inter-departmental interaction:

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. One university faculty member described COSIA:

> *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.*

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

Spin-off programs

Interviewees from both IHEs and ISEIs reported that through COSIA, they have increased capacity to provide spin-off 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.*

A different university faculty member said:
> *We also now have the ability to provide internships for COSIA students –the skills that they learned in the COSIA class, they put into practice and get something else to put on their resume.*

Another university scientist described spin-off opportunities of COSIA:

> *We have also been able to get our COSIA students involved in another grant program that we have that provides mentors for middle school students, called Mentoring Young Scientists.*

Institutionalization of the work

An important outcome of participation in COSIA in the ability of educators in IHEs, as well as ISEIs, to institutionalize the COSIA work to such an extent that there is increased capacity throughout the organization to continue to run the project and not be dependent on the staff that was initially involved in the partnership. At least two institutions (a university and an aquarium) have lost their initial individual COSIA leads to other projects but COSIA lives on, after responsibility was handed off 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.*

COSIA: AN EMERGING NETWORK

LHS: The Center of the Network

Associated with COSIA partner institutions' increased capacity to do the work of COSIA and to partner, 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 getting them started. LHS has been organized, responsive, and prompt in its efforts to foster and support the COSIA partnerships. Having a core curriculum 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. LHS has met that challenge. Through their centralized capacity, LHS is shepherding the mission 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.*

CONCLUSIONS AND SUMMARY STATEMENTS

The Potential For A Network Of Partnerships

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 plan to deepen and broaden their COSIA work, and as they situate the knowledge gained through COSIA within the broader field, they have carefully considered COSIA evolving into a sustainable network. Staff and participants have engaged in reflection and discussion on the extent to which COSIA is already functioning as an emerging network, to what extent it is desirable to become a full-fledged network, and what capacities need to be in place or enhanced to do so. In an effort to develop a sustainable network, the partners, as well as LHS, will need to create win-win relationships that will strengthen the existing partnerships, while making way for potential new partnerships.

Some of the individuals we have interviewed thus far have identified some of the potential advantages of COSIA growing a network of COSIA partnership sites: partners could share a common language, experience, and structure; partners could share resources, such as libraries, exhibits, and presentations; having more people involved means the goals of COSIA would enter the scientific community vernacular faster; a growing network would grow support for science literacy; more visitors would have a rigorous but enriching experience; partners could learn new ideas from others; there is the potential to share the work and ease the burden; and partners could leverage resources. As one COSIA partner said:

> *By growing the network, the strength, quality, and audience only improves.*

Of course, interviewees acknowledged that there could be disadvantages to growing a network as well. Partners would need to address limiting factors such as time, money, and institutions' idiosyncratic bureaucracies.

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 simply an expenditure for COSIA services, we view the investment as an opportunity to build capital for the organizations involved in COSIA, and to create opportunities and fuel for future valuable work.

We see investment in COSIA playing out in the following way:

1) National Science Foundation invests money in COSIA

2) Money initially helps develop products and services (in the form of COS course and COSIA instructors' manual, partnership manual, partner meetings, and orientation workshops)

3) Partnerships form around these products. (The course serves as the tool for meaningful work. A collective or partnerships forms an alliance or cadre of partners)

4) Through the work of the partnership activity, the investment in turn develops capital – human, political, and economic (knowledge is 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) The nascent COSIA network is an extraordinary structure with the potential to capitalize on and further leverage the capital developed through the COSIA products, services, and partnership activity.

In other words, NSF has provided the funds for good people to do work that is valuable to organizations, improves capital, and ultimately fuels future work. There is no question that the investment made in the COSIA project to date has yielded important benefits, including direct tangible benefits to informal educators, scientists and students. These benefits also 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 have 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, has been valuable to the educators and the students involved.

Furthermore, our studies support the proposition that participation in COSIA has contributed to the creation of strong partnerships. We have evidence that this form of a project works and that the specific local sites involved are generating 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 to be at the center of a nascent or emerging network. Through the emergence of a national network, COSIA is developing 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.

As partners have become smarter about their work in COSIA, they have 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 COSIA 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 COSIA 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? COSIA 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 might be better addressed through a network. One university faculty member described the need to meet 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 COSIA 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 challenges facing COSIA:

> *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.*

It is possible that experienced partners can be encouraged to develop their leadership capacity. Partners can then become hubs to disseminate COSIA – to serve as nodes of expertise for expanded COSIA partnerships. A COSIA leader described a strategy for expanding the reach of COSIA:

> *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.*

It can honor the work and expertise of the COSIA partners to be attentive to what they have achieved within the project and what they are particularly skilled at doing. We suggest that COSIA continue to improve the resources and tools – refine and disseminate handbooks and guides – while encouraging this local expertise. The tools and resources work in service of developing and continuing to support local, centralized, relevant expertise.

The COSIA project is generating 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 across this network and for growing the network. The next logical step to take in this work is to leverage the working assets the project has created in order to catalyze the knowledge sharing, mutual engagement, and support that is possible through a network. From here, COSIA would do well to continue to support the existing partnerships and allow them to flourish and evolve, while simultaneously expanding the reach of the network to bring on new partners. There is evidence that the emerging COSIA network is an effective mechanism for achieving the goals of the project and we believe the project is well positioned for future investment to build upon its accomplishments to date.

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