# STRENGTHENING THE CAPACITY OF INFORMAL SCIENCE EDUCATION AS A CONTRIBUTOR TO EDUCATION IMPROVEMENT:

## *A REFLECTIVE ASSESSMENT OF THE CENTER FOR INFORMAL LEARNING AND SCHOOLS (CILS)*

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INVERNESS RESEARCH

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# I. INTRODUCTION

The Center for Informal Learning and Schools (CILS) was funded for five years, 2002 - 2007, as part of the National Science Foundation's Centers for Learning and Teaching (CLT) initiative. CILS involved three partner institutions: The Exploratorium in San Francisco, the University of California at Santa Cruz (UCSC), and King's College in London, England (KCL). The broad aim of CILS was to strengthen the capacity of informal education research and practice to contribute to educational improvement through fostering connections among practitioners and researchers in both formal and informal settings. CILS engaged in several strands of work to address this aim:

- training in informal learning for doctoral students in sciences at UCSC and King's College;
- professional development for science museum practitioners, sponsored by the Exploratorium;
- research on informal learning, conducted by faculty and doctoral students at UCSC and King's College, often set within informal institutions; and
- the Bay Area Institute, an annual event that brought participants across CILS programs together with others in the field to share knowledge.

Inverness Research served as the external evaluator for CILS.[1] We brought a perspective to this role derived from 20 years of research on a variety of projects designed to bring the unique assets of informal science institutions to bear on efforts to improve science education in the formal system. Our observations over time suggest that informal science institutions are often important contributors to the improvement of science teaching and learning. However, we believe that informal science education is not yet sufficiently organized as a field, or domain, to sustain an infrastructure that has steady, high capacity to function optimally as a contributor. Our perspective on CILS was that in its scope and its aims, it had potential to develop real capacities and also generate lessons learned that could help advance efforts to develop this field and infrastructure.

This report draws from data gathered over the project's five years. Our purpose is to assess the ways in which and the extent to which CILS built critical capacities in the domain of informal science education. We think this assessment, and lessons learned from CILS' work, help make the case for ongoing investments in the development of informal science as a field and, ultimately, in the formation of a lasting infrastructure for educational improvement. We envision this report as being of interest to education leaders in informal science institutions, university researchers with an interest in

[1] Inverness Research studies investments in educational improvement, striving to bring insights and lessons learned to project leaders, funders, and the field. See www.inverness-research.org.

learning and teacher development in informal settings, and funders who see the need for ongoing development in this domain.

## II. EVALUATION FRAMEWORK

The framework guiding our evaluation work derived from a combination of NSF's vision for the CLT initiative and our own conception of CILS' potential as a galvanizing agent for the informal science domain.

### A. CILS as part of the CLT Initiative

NSF's Centers for Learning and Teaching (CLT) initiative had the broad goal of building the capacity of the science, technology, engineering and mathematics (STEM) fields to undertake education improvement efforts. Funded centers were not intended to provide direct services; rather, they were to build capabilities in key domains of STEM that are critically important to the support of national, state, and local improvement efforts. Each funded Center identified a domain within which it sought to build capacity: some focused on mathematics, others on science, issues of equity, teachers, or rural/urban settings.[2]

*CLT "Drivers"*

The success of the CLT initiative depended on funded Centers' development of five critical capacities. We postulated these capacity-building outcomes as "CLT drivers," meaning that they would drive the Centers' design and implementation efforts. The drivers:

1) create new **structures and programs** that support the ongoing development of the domain;
2) develop **leadership** in the identified domain;
3) forge and nurture new **relationships and connections** among those working in and around the domain;
4) generate, apply, and disseminate new **knowledge** for the domain; and
5) build **"centerness,"** i.e., develop entities that have the characteristics and stature of Centers.

The fifth driver required more definition than the others, which are more intuitively understood as being vital to capacity development for a domain. "Centerness" is a quality that has both external and internal facets. Internally, members of Centers (the

[2] See http://www.nsf.gov for a description of this initiative, a list of funded CLTs, and evaluation reports.

institutions and key professionals within them) should work together in complementary, even symbiotic ways, such that the whole of a Center's work and potential contribution becomes greater than the sum of its parts. Externally, Centers should interact with improvement efforts across their focus domain, both contributing to and drawing upon those efforts.
Much of our evaluation activity focused on gathering data related to these five drivers, and the body of this report is organized along these lines.

**B. Characteristics of the domain of informal science education**

CILS focused on the domain of informal science education. This domain includes a very wide range of people, institutions, and types of work: people who do university research on learning in informal contexts; those who study policies and practices in and around informal learning contexts and settings; those who lead informal science institutions and the educational programs within them; and those who establish and nurture relationships between the formal and informal domains. As a domain, informal science education has two notable characteristics with respect to its relationship to improvement of science education: first, it is ***important*** and second, it is ***loosely defined.***

*The importance of informal science education*

Informal science education is significant on a national scale. There are approximately 2,000 science-rich institutions of all types in the United States, including museums, science centers, zoos, aquaria, and arboreta. About 400 are science centers serving millions of people every year. These institutions contribute to science education in three major ways:

1) The exhibits and programs of science-rich institutions **provide large numbers of educators, students, parents and the general public with science learning opportunities** that are unavailable anywhere else.

2) Science-rich institutions are important **institutional partners in supporting the "semi-formal" domain**, i.e., organized education that occurs outside the mainstream school system. This growing domain involves science-oriented programs that take place in venues such as after-school and other settings (e.g., Boys and Girls Clubs, Community Science Workshops, YMCAs). The science-rich institutions can themselves house such programs, but they can also provide professional development for staff and curricular materials to other such efforts.

3) **Science-rich institutions provide professional development to science teachers, serving directly to strengthen the formal education system**. Some data suggest

that one-fourth of professional development offerings in science for elementary teachers occur in informal science-rich institutions.[3]

[3] "An Invisible Infrastructure: Institutions of Informal Science Education." An ASTC publication by Inverness Research Associates, 1996.

*The limitation of a loosely defined domain*

Science is perhaps unique, and certainly different from mathematics, in that there are thousands of cultural institutions across the country and around the world that are repositories of science learning materials and expertise. Not only do they serve the public, but increasingly, they have the capacities to contribute to the improvement of teaching and learning in schools. However, while the many activities within this informal domain are significant, historically, this domain has not been well organized or even conceptualized. People working in institutions in this domain—from universities, to museums, to schools—have never intersected well. In terms of a "field" where professionals are well linked as working assets, there are currently very few mechanisms and efforts that connect researchers to each other, researchers to practitioners, and practitioners to each other across formal and informal institutions. This looseness limits the capacity within this domain to contribute collectively or in steady, lasting ways to the strengthening of science in the formal education system.

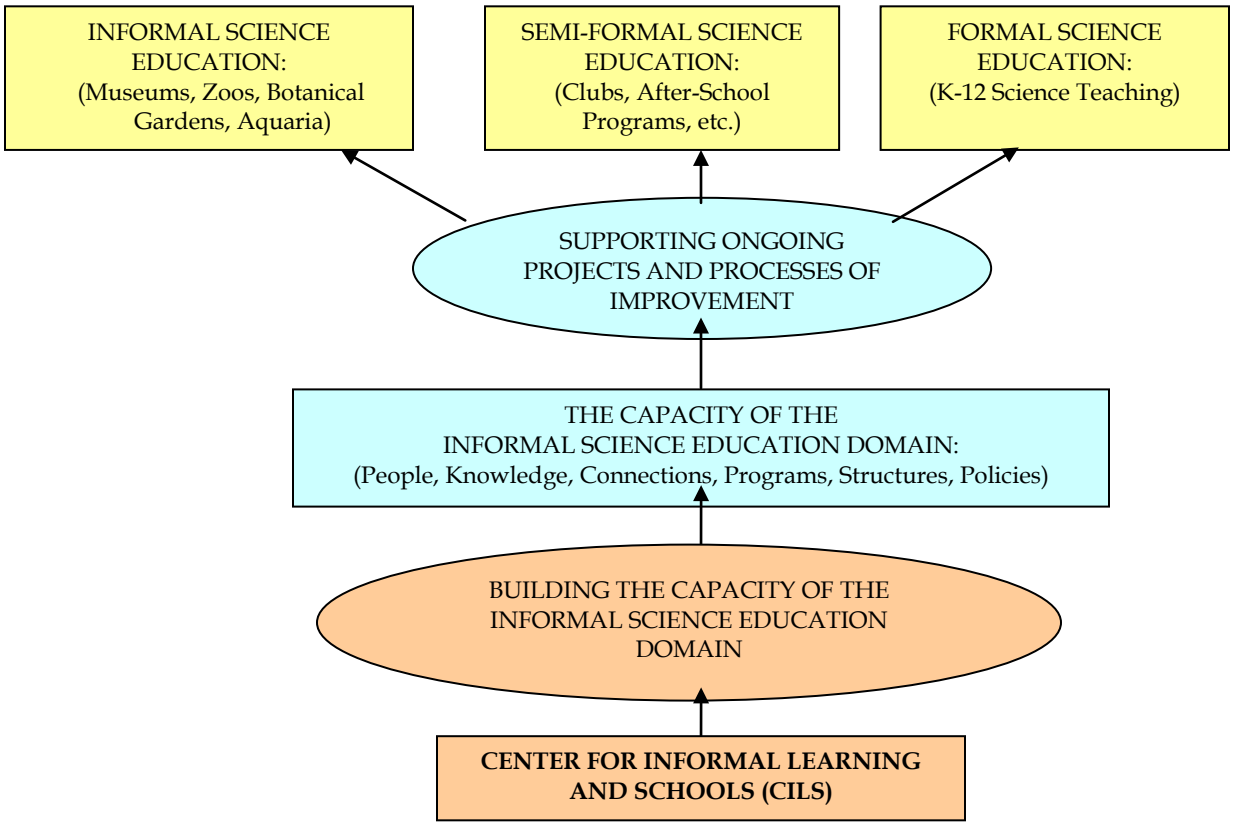
**C. The challenge and potential for CILS: To help create an improvement community and infrastructure for informal education**

This combination of significance and looseness suggests that there exists within the informal science education domain a strong potential for the development of a national, even international, "improvement infrastructure"[4] for science education. From the outset, we envisioned CILS as having the potential to provide a nucleus for building such an improvement community for informal science, and for defining and perhaps beginning to organize the improvement infrastructure. Through its core work of addressing the CLT drivers— forming new structures and programs, developing leadership, building knowledge, forging connections and relationships, and gaining stature as a Center—CILS could potentially both create and link together capacities that are vital to an improvement infrastructure for informal science education.

The diagram below portrays this vision of CILS. Through the pursuit of the CLT drivers, CILS engages in a long-term process of strengthening the foundational capacities of the informal science education domain. The strengthened domain, in turn, becomes better able to contribute to all of informal science education. It also becomes better able to support ongoing projects and processes that improve the teaching and learning of science in both school settings and semi-formal settings, such as after-school programs.

[4] We have used the idea of improvement infrastructure to describe the capabilities generated by NSF projects and NSF funding. The improvement infrastructure supports the operational education infrastructure that in turn supports teachers across the United States. For more on the improvement infrastructure see http://www.inverness-research.org/reports/ab_sustainability052002.htm.

Figure 1.
CILS as a Center that builds capacity of the informal domain to support science education improvement




**This report**

This report offers a summary assessment of the particular capacities that CILS built over its five years of operation, as well as our reflection on the extent to which CILS has laid groundwork for an improvement community and infrastructure that can strengthen informal science education's contribution to educational improvement. The assessment section below is organized along the five CLT drivers, and draws from data gathered all five years. Data sources include:

- Individual interviews and focus groups with CILS faculty, post-doctoral Science Fellows, CILS doctoral students and fellows, and Informal Learning Certificate (ILC) participants
- Surveys of doctoral students and ILC participants
- Observations of major CILS events and programs, including the Bay Area Institutes and ILC programs

- Center Review Panel independent report[5]

In addition to this summative report, we have also prepared modular reports highlighting two core programs of the Center: The CILS Science Fellows program, and the Informal Learning Certificate program (now called the Informal Learning Collaborative). These programs stand out as being well-designed and of significant value to the participants; they also stand as models that demonstrate both the need and potential for ongoing pursuit of the infrastructure-building work undertaken by CILS. For a more detailed discussion of these CILS programs, the reader is invited to read the modular reports, available at http://www.inverness-research.org/reports.html.

## III. ASSESSMENT OF CENTER CAPACITIES BUILT THROUGH CILS WORK

This discussion is organized around the five CLT drivers:

- Structures and programs
- Leadership development
- Relationships and connections
- Knowledge production and dissemination
- "Centerness"—becoming a visible entity that can help develop and organize the domain

### Structures and Programs

Over five years, CILS created several new structures and programs that were vital to its own capacity to develop leadership, create and disseminate knowledge, and build and sustain of relationships across the Center and beyond. On the whole these structures were both well-conceived and functional, and they stand as sustainable models for the field.

The Informal Learning Certificate (ILC) program provided transformational professional development for approximately 100 informal education leaders from 57 institutions across the nation. The scale of this program is significant: it works with enough educators to contribute to informal science education on a national, and even international, level. The program also has a deep and powerful impact on the individual participants who are connected by the shared, meaningful experiences they have had in the program. These connections have the potential to evolve into a powerful and sustainable network run by and for this community of practitioners.

[5] The Center Review Panel consisted of five experts in the fields of educational research, learning research, informal learning, and science education. This group coordinated with Inverness Research for the first three years to provide additional independent perspectives on the Center as it developed. Their findings were reported in a document that was submitted to Center leadership in the spring of 2005.

The Bay Area Institute brought together practitioners and scholars within, and eventually beyond, CILS for annual three-day symposia. This structure grew into an intellectually stimulating venue for sharing knowledge, meeting people, and creating relationships to build the field. The BAI could evolve into an ongoing forum that is central to the field as it develops.

CILS graduate programs at both KCL and UCSC have become important features of their respective academic departments, engaging faculty of all levels. These programs include new courses, existing courses with new emphases, research groups, connections with informal institutions as research sites, and other resources for the development of leaders and scholars in this field. In addition, in the last two years of CILS, a Summer School program was created to provide another opportunity for the CILS doctoral students, post doctoral scholars, and faculty to have in-depth conversations about their own and others' research.

The CILS website holds promise as a sustainable structure and tool that could serve to link people and ideas across the Center, as well as with those in the domain but outside of the Center.

*Reflection*

CILS created and sustained a number of strong programs and structures that have long-term potential for development in the domain. In surveys and interviews with doctoral students, the structures that allowed for connections among and between CILS participants were rated as the most valuable aspects of being a part of the Center. Center programs and events have made a mark on the domain landscape, and have provided a strong foundation upon which future work can be built.

**Leadership Development**

By leaders and leadership, we refer to people who have the position, stature, ability, knowledge, skill, and propensity to assume a leading role in ongoing development and improvement of the informal science domain. The informal education domain inherently demands cross-disciplinary leadership, research and practice. Without a specially focused investment, and without the structure and efforts of CILS, cross-disciplinary exchanges are not likely to happen.

Leading informal educators. Through the Informal Learning Certificate (ILC) program, CILS worked with approximately 100 museum professionals, many of whom are the managers of education departments in museums and who design and provide professional development for teachers as part of their work. In a survey administered

in 2006,[6] CILS participants reported becoming intellectually enriched, empowered, and motivated in their work at their institutions through their involvement with CILS. Highlights include:

- 76% of participants reported that the ILC program greatly contributed to their leadership in collaboration or partnerships with other museums
- 60% reported that the ILC program greatly contributed to leadership in their own institution beyond their department
- 60% reported that the ILC program greatly contributed to leadership in professional organizations of informal science education
- 55% reported that the ILC program greatly contributed to leadership within their own department at their institution
- 55% reported that the ILC program greatly contributed to leadership designing and implementing partnerships with local schools
- 45% reported that the ILC program greatly contributed to leadership in a local, state or national policy arena

In addition, nearly half (48%) the ILC graduates reported that the amount of work they do with teachers has increased since they started the program, and 54% reported that the type of work they do with teachers has changed since starting the program. Further a significant number of graduates reported that the ILC program contributed greatly to changes in their vision or goals for their work with teachers (54%), priorities for their work with teachers (41%), and ways they evaluate or assess their teacher programs (41%).

These results suggest that by taking advantage of the learning opportunities afforded them by the CILS program, these informal science educators have grown intellectually and professionally. Our interviews and direct observations of programs suggest that they have become more sophisticated in their understanding about ways their work can contribute to informal and formal science education domains. Further, this group of leading educators has evolved into the beginnings of a strong professional network, reaching beyond the time-bound certificate program. They believe strongly in the potential of this group to improve their own work and the ways they connect with schools. CILS is thus strategically leveraging leading practitioners in the domain who are likely to stay in the field and move it forward, contributing to improvement of practice in future years.[7]

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[6] A survey was administered by IR in Spring 2006. There was a 65% return rate for this survey. In the results we report, "greatly contributed" refers to the percentage of respondents who marked a 4 (a great extent) or 5 (a very great extent) on a 5-point scale.

[7] The leaders of this work at the Exploratorium have been seeking funding to extend the ILC program, now called the Informal Learning Collaborative, to include more participants and to draw on the expertise of the ILC "alumni."

Leading scholars: New and experienced. The informal domain is a field without clearly established professional niches, including academic tracks. Hence, it was an open question whether or not, through CILS, KCL and UCSC could attract established faculty as well as high-quality, graduate Ph.D. candidates in a field where there are no pre-established career paths.

In fact, CILS successfully recruited and retained **doctoral students in science education and cognitive psychology** who were of good quality.[8] Three types of scholars were supported by CILS: CILS doctoral students, science doctoral students with CILS affiliation (CILS Science Fellows), and university faculty with CILS affiliation.

The two graduate programs, courses of study, and research areas varied greatly, but they all involved a multi-disciplinary approach. UCSC students reported having more opportunities for collaboration and for drawing on resources outside of CILS. KCL students appeared to feel somewhat more isolated; also, the foci of their work seemed to be more geographically distributed. Despite these differences, both sets of graduate student experiences appeared to be coherent and mission-oriented, and both resulted in quite high levels of satisfaction among the graduate students.

In surveys administered in 2004 and again in 2006,[9] students rated their experiences quite positively. Highlights include:

- 81% said CILS provided good training and support in communication about informal science learning
- 75% said they gained a broad understandings of the field as a whole
- 69% said they learned how to collaborate with others in the field

When the 2006 survey is compared with the 2004 survey, there is a marked decline in some ratings, particularly the extent to which CILS prepared students in terms of their clarity about the place of their work in the landscape of the field (-23%), their familiarity with research techniques in the field (-23%), facilitation skills (-24%), proficiency in generating questions (-26%), and developing deep understanding of their content area (-28%). The least positive aspect of the doctoral program for the students was the extent to which they felt the program was preparing them as researchers. Overall, however, 81% of students reported being very satisfied with their programs, and all students reported that they are likely to continue working in the field upon graduation.

[8] As of Summer 2007, there were a total of 16 CILS doctoral students at UCSC in the education and psychology departments in various stages of the doctoral process, with one graduated (2005) and in a faculty position. At KCL there were five doctoral students (one graduated 2007) and six postdoctoral fellows (four of whom have completed their fellowship).

[9] The 2004 response rate was 95%, and the 2006 response rate was 73%.

The **CILS Science Fellows** are another group of 15 graduate students with strong potential to contribute to science education, especially over the long-term. They are individuals enrolled in natural science Ph.D. programs and who, through CILS courses, tele-conferences, seminars, and projects, learned about education theory and informal science education.

In interviews, the Science Fellows — who have solid backgrounds and interests in science — reported that CILS helped them develop their science communication skills, improve their ability to teach undergraduate science from an inquiry perspective, and become more directly involved in informal science institutions and schools. On the whole, they reported valuing their experiences highly. These benefits from CILS give the Science Fellows potential to contribute in multiple ways to the future improvement of science education. (See *CILS Science Fellows Report* for details.)

CILS has attracted and involved strong faculty members willing to contribute their time and energy — and that of their existing research groups — to enrich the knowledge base in this domain. Some **CILS faculty** became involved in new research directly related to the CILS mission; other faculty found ways to apply their existing research work and findings to the informal science education domain. Particularly noteworthy are faculty who became involved in CILS but whose backgrounds were marginally aligned, at best, with the CILS mission and vision. These faculty reported that their experiences and interactions with CILS doctoral students, other research faculty, the Bay Area Institute, and other opportunities greatly influenced their own professional and personal trajectories. For the faculty member quoted below, CILS provided an intellectual community and the means to fund new graduate students to expand and further a research agenda:

> *When I began to supervise one of the second-year students and took over two of the first-year students, a lot of my thinking space became devoted to learning in an informal context. Then as a result of the BAI, there was a woman here from the Natural History Museum, whom I have known for years, and she asked me to evaluate their public engagement work. I would have never gotten onto that line if it hadn't been for CILS…There are links that build up, and [involvement in CILS] has allowed us to really integrate what we do with the informal sector far more thoroughly.*

For another faculty member, CILS provided an opportunity to explore new territories:

> *I have always worked in departments of leadership and policy, and so we never got down to the instructional part very much. [In CILS] I am working with people from learning and teaching — it is at the heart of their work. For me, the puzzle is how to put that together with my interest in how the organization of school shapes learning and teaching. CILS gives me a new playground to run around in, to play with these ideas, and as a result of the course I taught [for CILS students], I realized that not only a comparison of*

*informal and formal settings can be useful, but perhaps some of my thinking about organizations could help CILS to conceptualize the intersection between the two. So, it has become a real intellectual thing for me, and a new focus for my own research.*

**CILS postdoctoral fellows**, who had obtained their doctoral degrees from other institutions in either the natural or social sciences, were positioned as researchers at all three CILS institutions. These post-docs had backgrounds in classroom teaching and museum education as well as in science subjects such as biochemistry. Coming from these multidisciplinary perspectives, they represented well the hybrid nature of the domain. As individuals with advanced experience in a range of real-world practitioner-based problems, as well as rigorous research methodologies, they understood the intellectual landscape of the field and were poised to become leaders in it. Fourteen post-doctoral fellows total were supported over the CILS period of CILS. Except for the two who were finishing their terms as of the writing of this report, they have moved on to positions in the field, including one UCSC post-doctoral fellow who took a tenure track position at Kings' College London.

*Reflection*

CILS developed leadership capacity by identifying potentially powerful individuals in diverse roles who possess strong inclinations to build and strengthen the field. CILS added to the capacity of existing leaders, developed new leaders, and invited strong researchers in other fields to apply their expertise in this field. Importantly, CILS worked to create leaders whom we refer to as "hybrids," that is, people with knowledge and skills in two areas, such as informal learning and science, or informal learning and socio-cultural theory, or informal and formal learning. The leadership development efforts supported by the Center have brought together ideas and expertise from multiple fields to build the capacity of the participants in ways that allow them to comfortably straddle the borders of existing fields of study, while contributing to the development of a new field. CILS' leadership development activity suggests that there is indeed a need for a Center to foster these kinds of interactions and that these leaders have potential to further define and guide the field.

**Connections and Relationships**

Education practitioners working in the informal science education domain (in museums, for example) tend to exist and work in communities and institutions isolated from one another. Also, faculty members and doctoral students each operate within universities and departments that normally do not foster cross-interactions. Moreover, there are rarely bridges between the informal and formal worlds, a gap which bespeaks CILS' reason for being. Thus, an important element of capacity-building for the CILS domain is to build bridges that cultivate relationships and interactions. These

relationships must foster interactions both within the domain and also with organizations that are beyond the domain but that are resources to it.

Within-domain relationships. We observed that CILS provided those who are centrally involved in informal science education with an intellectual and organizational nucleus, or center of gravity, and also provided them with a connection to the formal domain. Over the years, participants across CILS reported that they valued opportunities to interact, for example, through the Informal Learning Certificate (ILC) workshops, summer school sessions, the Post-doctoral Seminar in London, and the BAI. These events provided the opportunity for people involved in the domain (both researchers and practitioners) to share their work and learn from one another.

Below are comments from doctoral students, who repeatedly cited the connections and relationships that CILS helped foster as the greatest strength of their doctoral program:

> *CLS brings together a committed group of very good, very respected researchers from several fields. This has provided me with variety of perspectives in my program that I would not have had access to otherwise, and which has made me a more well-rounded student.*
>
> *The greatest strength of CILS is bringing together people from different domains, fostering the confidence that leadership roles require while also keeping us critically aware of issues that might be otherwise left at the periphery. The greatest strength of CILS is the professional community relations it fosters.*
>
> *The strengths of the CILS doctoral program are the connection with research professionals of the field and the sense of individuality allowed by faculty in research ideas.*
>
> *I feel that the conferences, summer school, and colloquia associated with CILS have been some of my best learning experiences in grad school. I think that the mixing of all types of researchers and practitioners at CILS center events have been invaluable to my graduate experience as these events expose me to much more than just my department. I would say the Center has done a great job of connecting me to professionals in the field.*

Importantly, participants in all events also reported that they need more opportunities and support to build and continue to strengthen the connections.

International relationships. CILS has engaged with and contributed to an international community of informal learning organizations, primarily because of its UK partner, Kings College London. CILS Principal Investigators report that the international aspect of the Center has contributed a greater diversity of research perspectives than might otherwise have been expected:

*The international connection has broadened CILS, has enabled it to build links with EXCITE[10] and obviously PENCIL[11] was part of that, but it has broadened the number of people who have been involved. Quite a few of the students and other people have actually made presentations at EXCITE and ASTC[12] conferences, which really are more practitioner conferences rather than what you would call research conferences. The focus has in some sense been about trying to raise the perspective of research within those communities. It has broadened the circle of influence of CILS.*

*The international part is really important, and actually core to what we were doing. I am always a big fan of living and learning from comparative studies and… thinking about the difference in systems, about how the informal-formals couple in Europe or the UK in particular. The US was actually quite enlightening to try to understand what is going on. I also think the variety of research perspectives was really an important thing to have in play within CILS.*

*My sense is that CILS has quite a presence in Europe and so that most of the folks who are working in science museums in this area are aware of PENCIL and the CILS connection. Their participation in the BAI has been great, and has really enriched the conversation… Many people came over[from Europe] for the BAI that were really key contributors and participants in the CILS community.*

*Reflection*

Building relationships is a long-term process that requires coordination, which requires support. CILS fostered broad and lasting connections within the domain, both nationally and internationally. All participants want continued and expanded interactions. It appears likely that the connections and relationships that CILS created left an indelible mark on the three primary institutions. As one PI stated, "I fully anticipate that the three institutions are going to be doing different kinds of work over the next five years because of CILS, [and] the collaborations will continue." At the same time, CILS fostered less interaction with those working outside the domain than within. While there was great strength in the diversity of faculty and students involved in CILS, there may also have been key partners and "outsiders" who were not effectively connected with the Center but could have contributed, such as researchers in the professional development of teachers. Ultimately, broadening the conversation is important to CILS' role.

**Knowledge Creation, Use, and Dissemination**

[10] European Network of Science Centres and Museums
[11] Permanent European Resource Centre for Informal Learning
[12] Association of Science and Technology Centers

A major dimension of the CILS mission was the **creation, use, and dissemination of knowledge** within and for the informal science education domain. CILS convened and supported individuals and groups across the Center to discuss, share, plan, and conduct research to build a knowledge base that could enrich and connect the informal and formal domains. CILS also worked to create a **research-rich intellectual milieu** in which graduate students, post-doctoral researchers, and informal education practitioners encountered organized knowledge in the domain and could develop their knowledge and skills.

Knowledge creation. Over the course of the grant funding, CILS faculty and students presented and/or published approximately 158 scholarly papers. CILS-related research varied from studies of learning in family settings, to the study of narrative and its role in understanding science concepts, to examinations of the design of museum professional development programs, to comparisons of formal and informal contexts and policy. CILS leaders sought ways to share and discuss all of these lines of research. They also wanted to organize them conceptually and create a context within which they would support the development of the informal domain as an improvement infrastructure. Ultimately, the consensus among CILS researchers whom we interviewed and the external Center Review Panel is that, while interesting questions were pursued under the CILS aegis, a clear, coherent Center–wide **research agenda** did not emerge. Rather, CILS leaders identified **strands of research** and associated research questions that might be opportune for current and future graduate students and post-doctoral researchers to address.

A doctoral student's comment reflects the challenge inherent in doing research in an as-yet undefined field:

> *Although CILS has provided an environment conducive to exposure to the academic fields of education, psychology, and science center practice, there remains confusion about exactly what the "field" consists of. This ambiguity drives a lot of our internal feeling of lack of cohesiveness. The experience has been research-rich, but somewhat unclear about what counts as important key research.*

In the Center Review Panel report submitted in March 2005, approximately two-thirds of the way through the funding cycle, the panel noted that the research effort would greatly benefit from taking a Center perspective to the questions and problems it was addressing at the various institutions. Specifically, they recommended then that the research effort attend to the "big picture of potential relationships between museums, schools, and home learning… a more articulated developmental picture in which early competencies and resources are more tightly connected to learning that happens later in life…[and]…[what] schools and museums [can] learn from each other about providing different…contexts for an effective landscape of professional development."

These suggestions were offered with the understanding that at the time, the CILS research work had necessarily been largely foundational. Furthermore, the panel noted that CILS' approach was not always straightforward, and that the creation of a new field often involves adjustments as the work progresses, as explained in the following:

> *[I]t is a little like beginning with several populations of organisms and attempting to create an ecosystem in which they all can live together. As in biological ecosystems, adaptive change is most likely to occur at the boundaries of the existing populations, where contact with other populations is most frequent. CILS students and postdoctoral fellows are those boundary-crossers. As such, they are the potential seed for a new field of research. Some adjustments of the subpopulations must occur as they come to grips with what it means to be living together as a common ecosystem, and as we discuss below, these adjustments are now well underway (CRP Report, 2005).*[13]

Thus, midway through the life of CILS, the panel recognized its great potential to create new and important knowledge for this emerging field. They also suggested that the next challenge for the Center would be to:

> *[I]dentify the most important and promising… agendas and ideas, and focus CILS participants on the genuine engagement in each other's research that can really bring the issues up a notch by asking how they can inform the new CILS field. Identifying the mechanisms and support to bring about this concentrated focus on issues of common interest and importance will be the next research-related challenge for the CILS leadership. It is this integrated work, and not a collection of related research products, excellent though they may be, that can best help to forge this nascent field (CRP Report, 2005).*

One structural challenge that constrained the development of the research agenda was that the research was not directly funded by the CILS grant; rather, it was expected as a derivative benefit of doctoral student support or existing faculty work. By the end of the grant period, the leaders of CILS acknowledged that the research effort did not reach the level of coherence or integration that they had once envisioned or that the CRP recommended. Nonetheless, they believe numerous discussions, debates, and attempts to outline a CILS-specific research agenda in the early years were not wasted. CILS leaders assert that, given the inherent challenges of working in an under-defined multi-disciplinary domain, the reviews and studies that were done were essential for creating shared research interests, the first step toward an agenda for the domain. They see this foundational work as paving the way for a more comprehensive framing of research opportunities that will define the future knowledge contribution of CILS.

We can observe, additionally, that these early efforts built a sense of identity within CILS among its academic and practitioner participants. In other words, while these

[13] The Center Review Panel produced a report in 2005 that was submitted to the CILS leadership.

efforts did not define a coherent, comprehensive research agenda for CILS, they did create a CILS research community and elements of a shared vision upon which to build future work. One CILS leader said:

> *I think talking about what a research agenda might be like is interesting, because it tends to feed individuals with what they are thinking about, and it also tells you who you want to have in conversation at places like BAI. So talking about the research agenda is important, but actually defining it concretely isn't.*

CILS leaders note, further, that while research became a focal point of NSF's Centers for Learning and Teaching (CLT) initiative after CILS was funded, CILS functioned best as a "capacity-building" Center, with its efforts concentrated in the area of illuminating the kinds of capacities needed to strengthen the informal domain and its links to the formal one. One CILS leader put it this way:

> *I think we have created knowledge about what kinds of capacities are needed. …part of what we have to do now is really distill and disseminate what we have learned that is needed in the field, which will include research, but will also include training, development, funding, and policy.*

Knowledge exchange and intellectual community-building. The Bay Area Institutes, as well as the London Postdoc Meeting and the two CILS Summer Schools (the first in London and the second at UCSC), are examples of ways the Center fostered multi-disciplinary interest in questions of consequence to the domain. The aim of the Postdoc Meeting was to promote discussion and sharing of research perspectives between King's and UCSC researchers, to enhance the quality of research produced at each institution, and to facilitate joint projects. The CILS summer schools were attended by CILS leadership, faculty, post-docs, and graduate students. A portion of the week was spent in large group discussions on topics related to informal science education, such as "the nature of science" or "equity and social justice in education." However, for the majority of the week, participants worked in small groups of four to five individuals. The primary purpose of these working groups was to allow the doctoral students to get feedback on their research — the topic, methodology, progress to date, and presentation. The summer school was widely regarded as a very generative and helpful component of CILS.

These programs demonstrated CILS' potential to create a learning community revolving around intellectual ideas emerging from a variety of research approaches. In interviews, participants at the 2007 BAI commented on their collective evolution:

> *This group is now more sophisticated and confident [compared to the first BAI]. As a group, we're moving forward collectively.*

*As a practitioner, I can speak more research. I've benefited from these relationships.*

*It struck me [how important people feel it is to] maintain identity [as informals] when we commingle [with formals], and how the conversations are substantially different than five years ago. What else do we need to learn so we can go beyond that question and concern? How do we engage in STEM education deeply and yet keep our strong identity as informals?. …We've created enough common language, and values behind our positions, and interests we've articulated. …this time the conversations are more fluid [and] we're able to articulate better what we know.*

*I'm thrilled by what I've been hearing today. When you engage in this kind of work, looking at your beliefs, values, etc., it takes at least five years! You've achieved clarification of what you are doing, what questions you're asking.*

In our most recent survey of doctoral students, some students' comments reflect the value of CILS in creating a research-rich environment:

*Through the annual Bay Area Institute and CILS doctoral student summer school sessions I feel that I have been immersed in a research-rich environment. The diversity of people who attend these events and the diversity of issues represented allowed me to learn about and contribute to the evolving knowledge in the informal science field. I am pleased with my experiences sharing research with others through CILS.*

*I feel that the conferences, summer school, and colloquia associated with CILS have been some of my best learning experiences in grad school. I think that the mixing of all types of researchers and practitioners at CILS center events have been invaluable to my graduate experience as these events expose me to much more than just my department. I would say the center has done a great job of connecting me to professionals in the field.*

*For my research field CILS has allowed me to make important connections to other disciplines that deal with similar issues and questions regarding informal learning. It has brought together a wide variety of researchers and practitioners which has resulted in important collaborations.*

CILS clearly made substantial progress in creating opportunities for participants to interact, share, reflect, and learn. While it remains to be seen whether or not the knowledge-generating community formed by CILS can survive without ongoing financial support, participants in these meetings, seminars, and events count them as critical moments in their professional development.

*Reflection*

CILS' research-related efforts over the years helped CILS leaders and researchers appreciate the difficulty of establishing and defining a new domain while engaged in an

effort to improve that domain. Observations from our own research and from the Center Review Panel suggest that the key accomplishments of CILS *vis-à-vis* knowledge creation include these: the creation of a fledgling community of researchers interested in some common issues and questions facing the field; structures and events that enabled this research community to come together to grapple with these issues and questions; and the beginning of a shared vision of what knowledge and capacities are needed to advance the knowledge and practice of the field.

**Centerness**

"Centerness" is a broad measure of CILS' capacity and place as an entity within the domain. An assessment of what might be called CILS' "internal face" would be the degree of strength and coherency of its vision and work; a reflection of its "external face" would be its visibility and role within its domain and beyond.

Internal face of Centerness. The informal science education domain is ill-defined, fragmented, and draws on multiple disciplines. Unlike other members of NSF's Centers for Learning and Teaching (CLT) initiative, CILS began with a membership that was diverse and disconnected. CILS strived to be a "big tent," inviting in many different members and groups, creating a Center that looked quite different from other CLTs. CILS began as three diverse institutions (Kings College London, UC Santa Cruz, and the Exploratorium) with complementary but quite different strengths. There were limited mechanisms for interaction and collaboration. There were people engaged in research and people leading education programs in informal settings, and the Center worked to find ways to involve them and have them interact. While the project directors at each site were full time, other key administrative and faculty leaders of CILS were engaged part-time. Perhaps by necessity, CILS was more distributed than centralized, more diverse than homogeneous. CILS might thus be more aptly thought of as a "network" or at least as a "distributed Center."

Initially, the three institutions that comprise CILS engaged in "parallel play," which is not surprising given their distinct structures, cultures and roles. Over time, they worked to evolve beyond that mode, eventually discovering mutual interests. One Center leader described the challenge, opportunity, and accomplishment this way:

> *Unlike the other CLTs that I am familiar with, CILS had as its purpose the cultivation of a nascent field, which is research on learning and teaching of science in informal settings, and then the relationship of that to school settings. Having two academic collaborators and then one non-academic setting, i.e., a center with multiple collaborators, seems to be a particularly functional structure given the purpose of establishing this nascent field. New fields are best set up by broad networks of individuals and organizations, so by having multiple collaborators, I think it broadened that effort and created more intersections between disciplines, never mind between institutions, that could foster the growth of a field.*

From the perspective of doctoral students, CILS developed more "centerness" over time. Below we display results of a survey on which we asked the students to rate the extent to which they agreed with statements related to CILS as a Center.

Table 1.
Doctoral students' perceptions of CILS as a Center

| | Not at all or small | Some | Large or very great |
|---|---|---|---|
| A place where students have a role and an opportunity to contribute | 6% | 6% | 88% |
| A place where faculty, students, informal practitioners and postdocs are connected, interact, and speak freely about the work associated with CILS | 0% | 19% | 81% |
| An opportunity to create a new field – informal learning and schools | 6% | 19% | 75% |
| A portal to the world beyond your own professional context and perspective | 6% | 19% | 75% |
| An opportunity for participants to learn about two or more disciplines and how to integrate them | 7% | 20% | 73% |
| A central node in the informal learning field that facilitates access to resources, faculty, practitioners, funding, and a sense of intellectual community | 13% | 25% | 63% |

In the same survey, 94% agreed to a great or very great extent that CILS offered them a sense of professional community.

External face of Centerness. Centerness also involves the degree to which the Center is recognized as a significant organization or entity within the domain. CILS increasingly looked for symbiotic relationships that crossed institutional boundaries or connected with other projects. We could observe that CILS became seen by some as a potential organizer of and for the field — a place to which people could contribute and from which they could learn. The last three BAI meetings functioned as a powerful bringing together of multiple interested parties to focus on the problems of the domain.

*Summary Reflection*

The evidence suggests that CILS moved along a trajectory of internal coherence, starting as a loose partnership characterized by parallel play, to a working partnership involving collaborations and connections, toward becoming a functioning Center. Moving along this trajectory took focused effort throughout the life of the project. Externally, CILS began to get traction as a place where people in the field could go to consult and learn. Overall, given the nature of the domain and the isolation and divisions within it, CILS made strides in bringing together the people and ideas to begin

building an improvement community for the field. CILS' struggle to achieve deeper collaborative results — for example, a coherent research agenda for the domain — speaks to the difficulty of this kind of effort within a fragmented domain and the need for the sustained work of a Center entity to support it.

## IV. CILS' LEGACY: EDUCATIONAL CAPITAL AND LESSONS LEARNED THAT CAN SERVE DOMAIN DEVELOPMENT

In this section, we highlight what we believe are key lessons learned from CILS and reflect on its contributions to the foundation of an improvement community and infrastructure that strengthens informal science's contribution to educational improvement.

### Creation of educational capital

CILS work produced multiple forms of educational capital needed for educational improvement**.** By educational capital we mean assets that informal and formal systems can draw upon to continue defining a field domain and to strengthen educational improvement efforts.

CILS Principal Investigators, Advisors, postdoctoral scholars, doctoral students, Science Fellows, and ILC participants all comprise a new **human capital** asset in the field of informal science education. CILS equipped each of these groups with new knowledge, skills, and attitudes they will bring to work in the field.

CILS faced the task of building capacity in a field that was not yet well-organized, especially with respect to contributing to the improvement of formal science education. Thus they were simultaneously conceptualizing and strengthening the field. CILS developed structures that enabled the creation of new and lasting connections, relationships and collaborations among and between people from different positions and perspectives in the field. The diversity of perspectives from the academic and non-academic partners, and the wide range of participants, has led to greater understanding across the field and, just as importantly, lasting relationships that will forge new work. This development of **social capital** was a strong focus of CILS' energy and attention, particularly in the final few years. It is likely that many of these relationships will extend beyond the life of the Center, functioning as a lasting asset to educational improvement.

Beyond the general asset that this social capital produces for the field, the growth of that capital also helped contribute to the forming of new research questions and new ways of thinking about practice and its relationship to research. CILS attempted to bring a research focus to the field and to set a standard for rigorous investigations in the

landscape of informal science learning and programs. With this focus, CILS created a new form of **intellectual capital** — new approaches to knowledge generation — to move the field forward. Social capital is an often under-appreciated contributor to intellectual capital because it is the relationships that generate the substantive interactions that excite the interests of researchers and spawn new research efforts.

Finally, CILS also created new **institutional capital** in the form of new people, knowledge, and propensities within the institutions to address issues of informal learning. At UC Santa Cruz, for example, the administration is working to institutionalize the Science Fellows program, and is considering making mathematics and science the focus of its new School of Education doctoral program.

**Lessons from CILS that have implications for future development**

Lessons learned from CILS have implications both for the challenges and for the potential to build on CILS' work to continue empowering the informal domain to make greater contributions.

Partnerships among diverse institutional partners are difficult to form and take time to operate effectively. Each of the institutional partners in CILS came to the partnership with unique cultural traditions. Finding the right people to participate, developing good communication structures, creating a workable management structure — all are critical for a functioning Center and were difficult to accomplish in five years within the distributed leadership structure of CILS. CILS had the additional challenge of having an international partner, which created some barriers to smooth and frequent communication. In a fragmented field requiring diverse participation, the five-year investment laid important groundwork for a strong, integrated, visible Center for the domain, but it is only groundwork nonetheless.

Sustaining a university-supported research agenda within the informal domain is especially challenging. The transition toward a research focus once the Center was up and running was difficult. There were no funds explicitly earmarked for research, which made it challenging for faculty to focus their efforts on the CILS research agenda. Rather, faculty tended to look for overlap between their extant research efforts and the goals for CILS research. Support for research in the informal domain is not as readily available as it is for the formal domain. A primary goal now for those who have been engaged in CILS research is to pull out the critical dimensions and concepts, and continue to build the argument for maintaining a research agenda in informal science learning at the respective partner institutions. An additional goal is to continue seeking a venue for communicating the findings of the research.

Bridging research and practice is difficult to accomplish in five years, especially for a new field, and with practitioners who have rarely, if ever, been exposed to research.

Much of the CILS research took place in museums and involved practitioners, so connections were made within that context. Still, bridging research and practice remains a major challenge. The attempts made by the ILC program were mostly aimed at providing practitioners with exposure and accessibility to research, not necessarily at providing direct translation. Also, the links between research and practice in CILS were not immediately obvious because of the many areas of research that are relevant to educational improvement. For example, many research projects (particularly those of the graduate students) focused on learning in informal contexts, while the museum educators' practice focused on teacher development programs or other connections between informal and formal education.

The boundaries between disparate disciplines can be fertile places for innovation. With its diverse institutional partners, as well as the diversity of points of view within the partner organizations, CILS researchers discovered that they were developing a kind of hybrid community of practice. The most interesting questions, they believe, lie at the borders between the disciplines of science, formal learning, and informal learning. For example, a group of researchers at UCSC and the Exploratorium proposed a symposium at AERA that addressed the boundary between school and non-school settings for science learning, drawing from both learning theory and organizational theory. Seeing the richness of these boundaries is a particularly exciting lesson. However, to make good on it will require ongoing investment since it can take time to find the right intersections to "mine."

**Building toward an improvement infrastructure and community**

CILS clearly took great strides forward in fulfilling its mission as a CLT — generating important assets for educational improvement and building cross-institutional relationships that have potential to form a lasting improvement community. CILS also invented programs and developed leadership that, if sustained, can serve as a strong foundation for a growing improvement infrastructure for the field. Expanding this community and sustaining the functioning of this infrastructure, however, is likely to require a steady source of targeted support.