Testimony of

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Chairman Lipinski, Ranking Member Ehlers, and distinguished members of the Subcommittee, I am Joan Ferrini-Mundy, Director for the Division of Research on Learning in Formal and Informal Settings within the Directorate for Education and Human Resources at the National Science Foundation (NSF). Thank you for the opportunity to testify about informal education in science, technology, engineering and mathematics – what we at the NSF call the STEM disciplines. In an era where we are all lifelong learners, the boundaries between formal settings for learning -- such as schools and universities -- and informal learning settings -- such as museums, cyberspace, and the media -- are increasingly blurred and porous. Against this backdrop, the NSF continues to provide leadership and scholarship for the ongoing transformation of STEM learning opportunities, for learners of all ages, backgrounds, cultures, and ethnicities, and in all settings.

Today I would like to address three main areas: the level and scope of NSF-funded research and development in informal science education; emerging research directions and challenges, including a focus on assessment; and the significance of informal learning environments in broadening participation in STEM.

Research on STEM learning in informal settings is not a new enterprise at NSF. The NSF's recognition of the importance of research about the STEM lifelong learning opportunities through out-of-school settings dates back five decades, to the formation of the Public Understanding of Science program in 1959 and the funding of studies of public knowledge of science. This emphasis has continued, most recently in the production of *Learning Science in Informal Environments* (2009), a report of the National Research Council of the National Academies. [1] This effort, funded by the NSF's Informal Science Education program, provides a synthesis of the research literature on learning in informal environments. It is generally acknowledged that the percentage of time that a person spends in formal education over a lifespan is relatively small compared to the time

[1] National Research Council (2009). *Learning science in informal environments: People, places, and pursuits.* Committee on Learning Science in Informal Environments. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, editors. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

available for learning outside of school. And, the *Learning Science in Informal Environments* report confirms on the basis of research that: "Everyday experiences can support science learning for virtually all people." (p. ES-2).

NSF-Funded Research and Development in Informal Science Education

Our signature catalyst for investment in this area is the Informal Science Education (ISE) program, which received its first appropriation in FY 1984. This was in response to recommendations that the federal government provide support for a wide range of informal learning experiences made in the 1983 report of the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology[2] . The report noted: "A great deal of education takes place outside the classroom. The most fortunate students receive experiences in museums, clubs, and independent activities … The child who has regularly visited zoos, planetaria, and science museums, hiked along nature trails and built model airplanes and telescopes is infinitely better prepared for, and more receptive to, the mathematics and science of the classroom."

The ISE program's primary goal is to promote lifelong learning of science, technology, engineering, and mathematics by the public and to advance the knowledge base, practice, human capacity and communities of professionals engaged in informal STEM education. Indeed, the infrastructure for free-choice learning provided by NSF's ISE program has been noted as being important in the development of the "informal science education" field[3]. Over the years, it has established television, radio, and giant-screen film as media for STEM education; funded major traveling and permanent exhibitions; catalyzed citizen science projects enabling the public to participate in actual research; and expanded community and youth programming, including after-school science. At the same time, it has supported ongoing professionalization and increased capacity of the field, as well as knowledge building through required evaluation, and research about learning in informal settings. Awardees over the past decade have included museums (28.2%), academic institutions (24.1%), media producers and television stations (20.8%), and many other types of developers and providers of informal science education. The involvement of academic institutions is increasing; in the current portfolio, roughly 35% of the awards are to institutions of higher education.

Today, this field is a diverse, creative, and interdisciplinary community of institutions, such as science centers, zoos, aquariums, and museums of many types, and professionals, including exhibit designers, film and television producers, media experts, after-school program developers, information technologists, scientists, and learning researchers. They share a passion and expertise for providing STEM learning opportunities to all people of all ages. To harness the talent and energy of these groups, the ISE program has dual commitments: building new knowledge about STEM learning in informal environments

[2] National Science Board Commission on Precollege Education in Mathematics, Science and Technology, *Educating Americans for the 21st Century* (Washington, DC: National Science Foundation, 1983, CPCE-NSF-04).

[3] Lewenstein, B. (2001). *Who produces science information for the public?* In John H. Falk (Ed.), Free-choice science education. New York: Teachers College Press.

through research and development of models, and reaching large numbers of children, youth, and adults with STEM learning and engagement opportunities. Keeping these dual commitments in appropriate balance and synergy is an important challenge in the management of the program.

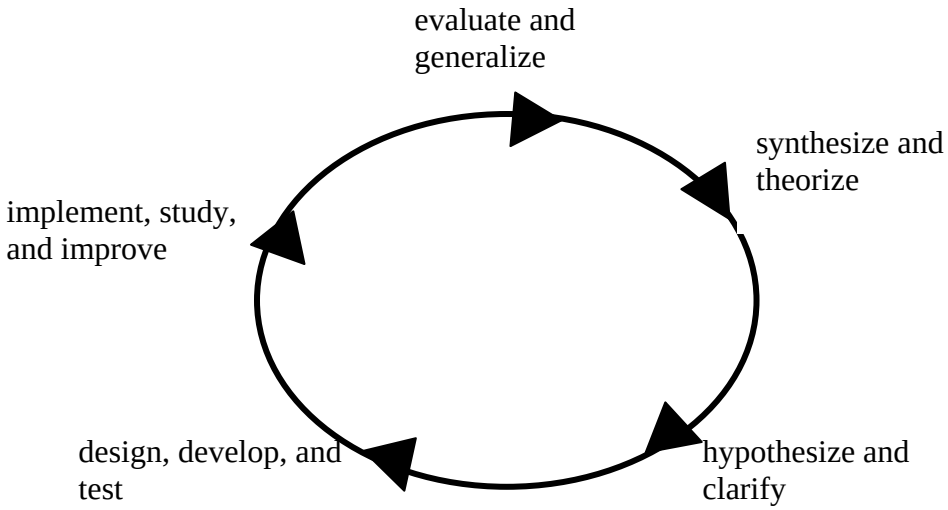
The budget in the ISE program for the past five years has been as follows (in millions):

FY 2004	*FY 2005*	*FY 2006*	*FY 2007*	*FY 2008*
$61.9	$62.8	$62.4	$63.5	$64.0

There currently are about 200 funded projects in the ISE portfolio, ranging from design and implementation of innovative museum exhibits, to the production of large-format films and television and radio series, to research studies to examine how informal learning opportunities promote science learning, to "citizen-science" efforts, to public engagement in science in the spirit of science cafés, to the development of virtual learning communities and serious games. In the past two years, ISE-funded projects have won major awards, including Emmys, the Peabody Award, the Webby, and the American Association of Museums Award of Excellence in Exhibition, as well as recognitions such as premiering at the Sundance Film Festival. This is a highly competitive program with a funding success rate of about 15%.

Based on the questions I received from the Subcommittee and the focus of the recent *Learning Science in Informal Environments*, my emphasis in this testimony is on research related to informal learning. The Informal Science Education (ISE) program, NSF's primary source of investment in this area, funds both research and development.

The ISE program is part of a broader effort at NSF to understand STEM learning and how to best engage people of all ages in it. The Division of Research on Learning in Formal and Informal Settings has a growing portfolio of funded research that is building knowledge about the processes of STEM learning and that examines the impacts of learning interventions such as school curricula or museum exhibits, and the reasons for those impacts. DRL-funded research is ongoing at various points in a cycle of research and development.



Projects range from those that generate hypotheses and describe STEM learning phenomena and constructs, to those that design highly innovative and potentially powerful learning interventions built on basic learning research, to those that test, implement, and refine these interventions and learning materials in specialized settings, to those that operate larger scale implementation and effectiveness studies for the most promising interventions, to – finally -- synthesis and theory-building that informs continued work in the cycle. DRL and its predecessor divisions and units have provided funding for research on STEM learning and education since the 1950s.

Across the Directorate for Education and Human Resources and NSF more broadly, there are several programs that also invest in efforts to engage learners in STEM outside of school settings, as part of the NSF commitment to the integration of research and education. For instance, in the Integrative Graduate Education and Research Traineeship Program (IGERT), scientists are engaged in communicating their work to public audiences.

Emerging Research Directions and Challenges

As hosts of new scientific findings and STEM issues of national interest to the public emerge daily, and in today's rapidly changing context for communication and information-sharing, it is essential to have a robust body of research and evaluation that maximizes the potential impact of investments in informal science education. We need to know much more about how to motivate and interest learners in STEM topics. We need to understand what areas of science lend themselves best to learning in informal settings.

We need to study how learning in informal settings can be most powerful as an impetus for broadening participation in STEM careers. And, we need to conduct research about the public's attitudes, interests, and knowledge as a basis for their informed engagement with the science that affects public policy as well as their daily lives.[4] The National Science Board's *Science and Engineering Indicators* volumes report on the levels of public attitudes and understanding of science and technology, recognizing that this is one barometer of the nation's readiness to engage in solutions to the scientific problems of the day and for its citizenry to have the scientific literacy necessary to sustain their own personal science-related decision making. Research in all of these areas, and others, is essential to ongoing strategic investments in the models and resources that are produced for learning in informal settings.

The *Learning Science in Informal Environments* report makes recommendations about needed research on: tools and practices that contribute to learning, learning strands, cumulative effects, and learning by groups, organizations, and communities. Through such syntheses, together with published research studies, web databases of evaluation reports, professional meetings and NSF-sponsored principal investigator meetings, the growing body of research about informal learning is communicated to practitioners to help inform their work. This research is also shared internally through seminars and workshops to help NSF staff remain abreast of developments in the field.

As the informal science education field matures, part of the needed capacity-building is to expand expertise and interest in research and evaluation, and to build the research base. NSF's investments in this area of capacity-building and knowledge-building are increasing. One strategy in this area was the establishment of the **C**enter for **A**dvancement of **I**nformal **Science E**ducation (CAISE), a resource center funded by the ISE program. In a review of the 548 ISE projects funded over the period 1998 through 2008, CAISE found that 60 projects had research about informal learning as a primary objective, and 37 as a secondary objective. These 97 research-oriented projects represent an investment over ten years of about $128 M. This indicates that approximately 15% of the overall ISE investment over this period, which includes development and implementation of a wide range of informal learning resources, is directed toward improving understanding of the use and impacts of such resources through research.

In addition to the ISE program, NSF's Research and Evaluation on Education in Science and Engineering (REESE) and Innovative Technology Experiences for Students and Teachers (ITEST) programs support research on learning in informal environments. For example, in its most recent solicitation the ITEST program calls for research to address such questions as: "What does it take to effectively interest and prepare students to participate in the science, technology, engineering, and mathematics (STEM) workforce of the future? What are the knowledge, skills, and dispositions that students need in order to participate productively in the changing STEM workforce and be innovators, particularly in STEM-related networked computing and information and communication technology (ICT) areas? How do they acquire them? How can the Nation's burgeoning

[4] See Office of Science and Technology and the Wellcome Trust (2000*). Science and the public: A review of science communication and public attitudes to science in Britain.* (p. 4)

cyberinfrastructure be harnessed as a tool for STEM learning in classrooms and informal learning environments? How can we assess and predict inclination to participate in the STEM fields and how can we measure and study the impact of various models to encourage that participation?"[5]

The Center for Informal Learning and Schools, funded by NSF's Centers for Learning and Teaching Program in 2002, has as its primary objective to create a program of research, scholarship, and leadership in the arena of informal learning and the relationship of informal science institutions and schools. This partnership among the Exploratorium, King's College London, and the University of California Santa Cruz, is undertaking research about such topics as explanation and communication, structures that support informal learning, and the design of learning environments. Within the REESE portfolio, there are 11 projects currently underway, representing a total investment of about $7 M, that are specifically examining issues relevant to informal learning. These range from a project that is studying how fundamental biological concepts are understood in different learning contexts and by different cultural groups (Bardeen, Fermilab), to a study of indigenous-heritage communities' ways of learning about scientific ideas (Rogoff, University of California Santa Cruz), to a study of how to improve connections between formal and informal learning settings (Schwartz at Stanford University, and Biswas at Vanderbilt University.)

Informal learning environments are voluntary learning settings; the learner can walk away from the exhibit, change the television channel, or click to a new website. Thus in addition to measuring what is actually being learned in such settings, the matter of determining what will engage learners and hold their attention is a crucial topic for researchers in this domain. This includes aspects such as understanding which scientific topics will engage learners, what kinds of features of an exhibit or program will hold attention, and what sorts of activities will encourage continued participation. The ISE program has funded efforts in all of these areas, although this clearly needs to be seen as an emerging, interdisciplinary area of research. Cognitive scientists traditionally have been more interested in learning as it occurs in school settings, although we are noticing increased proposal pressure in ISE-relevant research over recent years.

The professional wisdom and craft knowledge resident in the informal science education community, when tested and strengthened through research and evaluation, stands to inform some of today's most pressing educational challenges. In particular, because of the porous boundaries between the formal and informal learning communities, a focus on the connections between informal and formal learning environments is important. For example, the need to provide the nation's K-12 STEM teachers with mechanisms for keeping their science knowledge current in a cyber era can be informed by what is already known from the informal science learning community's accumulated wisdom about voluntary learning. By their very nature, informal learning organizations are positioned to be innovators in the type of hands-on, direct contact with the world of science that is seen by many as crucial in student learning, and research to illuminate

[5] See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5467

such learning environments stands to inform K-12 formal education.

There are major challenges in this research domain, as well as some promising tools and resources. Challenges are most prevalent in determining what outcomes should be expected in informal learning environments, and what metrics are best for measuring them. There are theoretical issues of "ecological validity" – museum-goers don't expect to take a formal test after a casual visit. Frank Oppenheimer once said "no-one ever flunks a museum." And, because of the self-directed nature of this learning, diverse learners (ranging from young children to older adults) will be interested in, and will learn, different things. The experiences are often brief and fragmented, and so it may not be reasonable to expect depth of content learning from a single exposure, although they may be particularly memorable and stimulate further engagement. In dynamic, open, voluntary learning environments it is hard to establish control groups and to deal adequately with human subjects issues. Promising approaches to addressing these challenges include interdisciplinary efforts that bring together informal science educators, educational researchers, psychologists, sociologists, and assessment experts; capacity building among evaluators to understand both the constraints and affordances of evaluation in informal learning settings; strategic use of common instruments when efforts have overlapping goals; and design of innovative instruments and approaches. This might involve, for instance, using physiological measures to track learning-related emotions, or building stronger theories about culturally responsive evaluation, or constructing new and appropriate outcome goals for learning. One resource that has been well received is the ISE-funded *Framework for Evaluating Impacts of Informal Science Education Projects* (NSF, 2008). This is a guide for ISE projects which includes such material as "Tools, Tips, and Common Issues in Evaluation Experimental Design Choices." The NSF, through the Division of Research on Learning in Formal and Informal Settings, is committed to playing a leading role in advancing research and development in the area of informal science education.

Informal Learning Environments in Broadening Participation in STEM

Building a STEM workforce that draws on the best talents of all in the society, reaching out to groups that have been underrepresented in STEM , and promoting a STEM-literate public all are central to NSF's mission. NSF's *Strategic Plan, 2006-2011*, includes as a strategic goal "Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens." In particular, the plan notes: **"**NSF will improve STEM literacy by developing new strategies that explicitly encompass both formal and informal education, with a focus on strategies that have an impact on the nation's critical need for a citizenry literate in science and technology, a skilled workforce, and a vibrant research community." (p. 8).

A number of ISE projects are specifically concerned with engaging learners from groups traditionally underrepresented in STEM. For example, the "Urban Bird Gardens: Assessing the Interest of Latino Communities in Citizen Science" project (Dickinson, Cornell University), and the "Native Science Field Centers" (Satchatello-Sawyer, Hopa Mountain) are funded with ISE support. And although the ISE program is the

Foundation's flagship program in this area, there are a number of efforts across NSF that recognize the particular potential of informal learning opportunities as a resource for broadening participating in STEM fields and make investments to advance this potential.

I have already mentioned the Innovative Technology Education Experiences for Students and Teachers (ITEST) program, which provides funding for research and development projects for K-12 students in out-of-school settings to encourage STEM workforce participation, especially by students from groups traditionally underrepresented in STEM. Also managed in the Division of Research on Learning in Formal and Informal Settings is the Communicating Research to Public Audiences (CRPA) program With CRPA, researchers funded through NSF's Research and Related Activities directorates can receive new awards to help them communicate their scientific results to the public. Other divisions in the Education and Human Resources directorate also fund projects to broaden participation in science using informal science learning materials as a basis -- notably a number of efforts in the Division of Human Resource Development that work to engage women, people with disabilities, and underrepresented minorities in STEM learning. The "Adolescents' Identification with Televised Portrayals of Male and Female Scientists" study (Steinke, Western Michigan University), through the Gender Studies in Education Program, is one such example.

I find that there is enthusiasm across NSF about informal learning opportunities as means of sharing the exciting and motivating aspects of science with diverse audiences, and recognition of the great potential of these informal learning venues for engaging youth who may not thrive in the formal education system. For example, several studies of museum-based and after-school programs have shown evidence of supporting statistically significant academic gains for youth, particularly when they draw on local issues and the children's prior interests.[6]

Across the Foundation there are efforts to broaden participation through informal science education. The NISE Net initiative, a collaborative effort across seven NSF directorates, is building public awareness and engagement about nanoscale science and engineering at more than 100 sites nationally. Led by researchers at three science museums, the project's goals include helping museum visitors understand the properties of new materials, along with the possibilities they present in areas such as medicine, security, and energy, as well as their potential societal implications. In another example, the International Polar Year provided opportunities for cross-NSF collaborations, particularly between the Office of Polar Programs and the ISE program, for major investments in innovative and exciting informal STEM learning. Among them was PolarPalooza, bringing polar scientists and their gear to sites around the country, as well as films, Web sites and science blogs bringing polar science to Americans of all ages and from all communities. In the Directorate for Geosciences, the "Science and the City: Fusion of Formal and Informal Learning Experiences into an Innovative Geoscience MA-Teacher Program" prepares program teacher graduates to integrate the resources of their city into their teaching. And, the project "Incorporating Cultural Tools for Math and Computing

[6] See Chapter 7, Diversity and Equity, in *Learning Science in Informal Environments*, NRC, 2009.

Concepts into the Boys and Girls Clubs of America", funded through the Broadening Participation in Computing Program in the Directorate for Computer Information Science and Engineering, uses culturally responsive approaches to attract and retain high school students to computer science.

In summary, the NSF has been able to build a diverse and dynamic portfolio of research, development and model-building to promote the learning of all people, at all ages, through a range of informal science environments, and including the cyber world. This portfolio is increasingly robust in the area of research about learning in informal settings and the knowledge base that is so essential in this area is growing in significant and useful ways. In closing, I want to thank the Subcommittee for this opportunity to share with you this information about the investments made by NSF in research and development to advance and foster increased public scientific literacy and development of the STEM workforce through informal science education.

Mr. Chairman, this concludes my remarks. I would be happy to answer any questions.