

BEYOND THE CLASSROOM: INFORMAL STEM EDUCATION

HEARING BEFORE THE SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

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BEYOND THE CLASSROOM: INFORMAL STEM EDUCATION

THURSDAY, FEBRUARY 26, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:00 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Daniel Lipinski [Chair of the Subcommittee] presiding.

HEARING CHARTER

**SUBCOMMITTEE ON RESEARCH AND SCIENCE
EDUCATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES**

**Beyond the Classroom:
Informal STEM Education**

THURSDAY, FEBRUARY 26, 2009
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

The purpose of the hearing is to examine the role of informal environments in promoting science learning. The Subcommittee will explore the potential for informal science learning to engage students in math and science in ways that traditional formal learning environments cannot, as well as the ways in which informal science education can complement and enhance classroom science studies. Furthermore, we will receive testimony on the National Academies report, *“Learning Science in Informal Environments: People, Places, and Pursuits.”*

2. Witnesses:

- **Dr. Joan Ferrini-Mundy**, Division Director, Division of Research on Learning in Formal and Informal Settings, Education and Human Resources Directorate, National Science Foundation.
- **Dr. Phillip Bell**, Co-Chair, National Academies report *“Learning Science in Informal Environments: People, Places, and Pursuits,”* and Professor, College of Education, the University of Washington, Seattle.
- **Ms. Andrea Ingram**, Vice President of Education and Guest Experiences, Museum of Science and Industry–Chicago.
- **Mr. Robert Lippincott**, Senior Vice President for Education, the Public Broadcasting Service (PBS).
- **Dr. Alejandro Grajal**, Senior Vice President of Conservation, Education, and Training, the Chicago Zoological Society.

3. Overarching Questions:

- What is the role of informal environments in educating students and the public about Science, Technology, Engineering and Mathematics (STEM)? In what ways can informal education contribute to and enhance classroom learning? Are there areas that informal environments are uniquely positioned to address? What role can informal education play in broadening participation and promoting diversity in STEM fields?
- What are the key factors in successful partnerships between informal science organizations and formal education institutions, including both K–12 and higher education? What opportunities for partnerships exist with the private sector? How have both museums and educational media providers had to adapt to meet the needs of schools and states? How can K–12 schools and institutions of higher education take advantage of informal learning environments to meet their needs?
- What kind of research is being done on informal science education to assess its evolving role and effectiveness? What metrics exist to assess and evaluate informal learning environments, and what are the barriers to developing better metrics?
- What are some of the major challenges and opportunities that lie ahead in the field of informal science learning? What support could federal research agencies provide to most effectively contribute to the development and implementation of informal STEM education activities?

4. Background

There is now a consensus that improving science, technology, engineering, and mathematics education is critical to the Nation's economic strength and global competitiveness in the 21st century. Reports have emphasized the need to attract and educate the next generation of American scientists and innovators. For example, the National Academies' 2005 report, *Rising Above the Gathering Storm*, recommends that the Nation increase its talent pool by vastly improving K–12 science and mathematics education. This recommendation was embraced by the *America COMPETES Act* which was developed by the Science & Technology Committee in the last Congress and was signed into law in August of 2007. Many in the STEM educator community have argued that in order to improve STEM education, we must draw on a full range of learning opportunities and experiences, including those in informal, non-school settings. Reports by both the National Science Board¹ and the Academic Competitiveness Council² cited informal education as an integral component of our nation's education system.

Informal Education

Informal science education can take place in a variety of places and through a wide variety of media such as science centers and museums, film and broadcast media, aquariums, zoos, nature centers, botanical gardens, online games, and after-school programs. It is widely held that informal learning can happen in everyday environments and through everyday activities as well. While it can be difficult to define informal education, the term tends to broadly refer to any opportunities for learning that take place in non-traditional, non-school settings.

National Academies Report on Informal Science Learning

The Committee on Learning Science in Informal Environments was established by the National Research Council (NRC) of the National Academies to undertake a study to examine the status of, and potential for science learning in informal environments. The National Science Foundation (NSF), a principle sponsor of research in informal science education, provided support for the study. In January 2009 the National Academies Committee released a report entitled *Learning Science in Informal Environments: People Places, and Pursuits*,³ summarizing the key conclusions of the study and providing recommendations for future research and practice. The Committee found, among other things, that there is ample evidence to suggest that science learning takes place throughout the life span and across venues in non-school settings. The Committee outlined and examined four categories where informal learning often takes place: everyday experiences, designed spaces (such as museums, science centers and zoos), non-school educational programs, and science media. The report summarizes the conclusions drawn from the research reviewed by the Committee, and offers recommendations for practice and research to exhibit and program designers, front-line educators, researchers and evaluators.

A key issue addressed in the report is the need to effectively evaluate and assess informal STEM education. Assessing learning in non-school settings can prove difficult since informal settings for STEM learning typically do not use tests or grades. Yet, there tends to be a general agreement that it is important to evaluate learning outcomes in order to improve informal STEM programs and activities. Another key issue highlighted in the report is the role of informal STEM education in promoting diversity and broadening participation. The Committee found that informal environments can have a significant impact on STEM learning outcomes in historically under-represented groups, and informal learning environments may be uniquely positioned to make STEM education accessible to all.

5. Federal Support for Informal STEM Education

Informal STEM Education Support at NSF

STEM education research and development activities are funded out of a number of federal agencies, with NSF being the primary source of support for STEM education research. Historically, NSF's mission has included supporting and strengthening the Nation's STEM research and education activities at all levels. NSF carries

¹National Science Board (2007). Science, technology, engineering, and mathematics (STEM) education issues and legislative options. In R. Nata (Ed.), *Progress in Education* (Vol. 14, pp. 161–189).

²U.S. Department of Education (2007). *Report of the Academic Competitiveness Council*. Washington, DC: Author.

out this mission by funding STEM activities ranging from teacher training and curriculum development to informal education and research on learning.

Many of the Foundation's STEM education and research activities are housed in the Directorate for Education and Human Resources (EHR). EHR support for research on learning and STEM education is largely funded through its Division on Research Learning in Formal and Informal Settings (DRL). The FY08 budget for DRL was approximately \$209 million. One of the chief informal STEM education programs funded through DRL is the Informal Science Education (ISE) program. ISE invests in projects that are designed to increase interest and understanding of STEM through informal learning experiences, with a particular emphasis on projects that seek to inform and strengthen informal STEM education nationally, and have the potential to make a strategic impact on the field as a whole. The FY08 budget for ISE was approximately \$66.0 million.

While the majority of the Foundation's STEM education support comes out of EHR, there are a variety of STEM activities being funded across the research directorates. One such example, the Centers for Ocean Sciences Education Excellence (COSEE) program, housed in the Geosciences Directorate in the Division of Ocean Sciences (GEO/OCE) has a strong informal education component. The COSEE program invests in projects that connect scientists with educators in formal settings as well informal settings such as museums and aquariums. Another example is the International Polar Year awards in NSF's Office of Polar Programs (OPP). Such awards fund formal and informal interdisciplinary projects aimed at educating the public about the polar regions. IPY projects have ranged from museum support and teacher development programs to film projects documenting polar marine ecosystems in Antarctica.

Support for Informal STEM Education at Other Agencies

The other mission agencies within the jurisdiction of the House Science & Technology Committee also support STEM education, including informal STEM education, through a variety of mechanisms. While it is not possible to provide budget information regarding all the informal science education initiatives at the agencies at present, there are a few notable programs that serve as examples of agency support of informal STEM education. The National Aeronautics and Space Administration (NASA) Informal Education Division has recently initiated its NASA Explorer Institute (NEI) program, designed to bring together members of the informal education community and NASA staff to facilitate discussions on how to best utilize NASA missions to educate students and the public about STEM. NEI supports the informal science education community by providing NASA-related professional development opportunities, STEM teaching tools and other development projects for informal STEM educators at NASA field centers. Another NASA activity, the NASA e-Education programs develop research-based products and services specifically designed to enhance both formal and informal education. At the National Oceanic and Atmospheric Administration (NOAA), the new NOAA Education competitive grant program funds projects that bring together formal and informal education institutions to create projects that promote environmental literacy and build public understanding of our global system and the interconnectivity of oceanic and atmospheric processes.

It is difficult to identify all the informal education programs since a comprehensive database of STEM education programs within the federal agencies does not exist at present. Many STEM education initiatives are clearly identified within their respective education offices and budget lines, but the important STEM activities embedded within the other agency mission directorates or program offices are much harder to identify. For that reason, Committee staff has undertaken the task of creating a comprehensive database of STEM education programs and activities within the six mission agencies.

6. Questions for Witnesses

Dr. Ferrini-Mundy

- What is the current level of support and the scope of NSF-funded research on informal STEM education? How much of NSF's research support in this area is directed to academic researchers and how much to providers of informal science education, or consortia thereof?
- What metrics and methodologies exist for evaluation and assessment of informal education environments? What are the barriers to developing better metrics? What is or should be NSF's role in developing those metrics?

- How can informal STEM education environments help NSF achieve its mission to broaden participation in STEM? To what extent are informal learning environments incorporated into programs to broaden participation managed elsewhere in the Education and Human Resources Directorate or throughout the Foundation? How do you communicate relevant new findings supported by your division to colleagues who manage those programs?

Dr. Bell

- Please summarize the findings and recommendations of the National Academy of Sciences report, *“Learning Science in Informal Environments: People, Places and Pursuits.”*
- What do we know about how students and the general public learn in informal environments? What don’t we know? How can we effectively evaluate informal learning environments? Is the current level of support for research in these areas adequate?
- Please provide an overview of your own groups’ research on informal education at the NSF-funded Learning in Informal and Formal Environments (LIFE) Center at the University of Washington.

Ms. Ingram and Dr. Grajal

- What is the role of informal learning environments, such as [museums/zoos], in educating students and the public about Science, Technology, Engineering and Mathematics (STEM)? In what ways can institutions such as [museums/zoos] contribute to and enhance classroom learning? In what ways can and have informal STEM education institutions, such as [museums/zoos], provided professional development for teachers?
- What role can informal education play in broadening participation and promoting diversity in STEM fields? What are informal education institutions, such as the [museum/zoo], doing to engage and educate diverse populations?
- Please describe any partnerships the [museum/zoo] may have with formal education institutions, including both K–12 and higher education. What have been the key factors to the success of such partnerships? How have informal STEM education institutions such as [museums/zoos] had to adapt to meet the needs of schools and States?

Mr. Lippincott

- What role can digital and electronic media play in educating students and the public about Science, Technology, Engineering and Mathematics (STEM) in the 21st century? In what ways can media be used as a teaching tool in the classroom? In what ways can and have educational media providers, such as PBS, provided professional development for teachers?
- What role can informal education play in broadening participation and promoting diversity in STEM fields? What are media providers, such as PBS, doing to engage and educate diverse populations?
- Please describe any partnerships PBS may have with formal education institutions, including both K–12 and higher education. What have been the key factors to the success of such partnerships? How have media providers had to adapt to meet the needs of schools and States?

Chair LIPINSKI. This hearing will now come to order.

Good morning. This is the first hearing of the Research and Science Education Subcommittee for the 111th Congress, and as such, it is my first hearing as Chair. I am very happy to have Dr. Ehlers here as the Ranking Member on the Committee. We have a great interest in STEM education. It is very fitting—I have a degree in engineering, Dr. Ehlers, of course, is a physicist, and we are Co-Chairs of the STEM education caucus, so I am very happy that we are holding this as our first hearing here this morning.

While we often examine and discuss ways to improve STEM education in the classroom, we rarely look at the many opportunities for learning elsewhere. A great deal of learning happens throughout our lives in everyday activities, from having a conversation at the family dinner table or watching a show on television, to attending a summer camp at a zoo or taking a trip to a museum. Not just students but the general public are exposed to opportunities for science learning through informal education every day. Today we will explore the ways in which informal learning institutions are uniquely positioned to attract and educate the public about STEM issues, as well as the role of informal institutions in contributing to and enhancing formal education in the classroom.

Today, we will hear from witnesses who are engaged in informal STEM education in a range of settings and capacities. I look forward to hearing the witnesses provide insights regarding the benefits and challenges of informal STEM education and the state of research on how students learn STEM in informal settings, as well as recommendations for moving forward.

The Science and Technology Committee, and our subcommittee in particular, has made STEM education a top priority. We have heard time and again that we need more STEM educated graduates and teachers if we want to compete in the global economy of the 21st century. A 2005 National Academies report, *Rising Above the Gathering Storm*, recommended that the Nation increase its talent pool by vastly improving K–12 science and mathematics education. For that reason, in the last Congress, the Committee developed and the President signed into law the *America COMPETES Act*, which included many provisions specifically aimed at improving STEM education in our country.

Educating more highly qualified STEM teachers and enhancing the teaching skills and content knowledge of existing STEM teachers was the top recommendation of the *Gathering Storm* report, which became the basis for the teacher education and professional development provisions in the COMPETES Act. I hope to hear today from our witnesses about the ways in which informal education institutions, such as museums, zoos, and educational media providers, can and do offer teacher training and professional development tools for our nation's STEM teachers.

I am also interested in the role of informal education in producing a more diverse pool of scientists and engineers through programs and policies that attract individuals from groups under-represented in STEM fields. I know some of our witnesses have been engaged in programs that address this issue, and I look forward to learning more about ways in which informal STEM environments

may be uniquely positioned to make STEM learning accessible and exciting to a broader demographic.

I believe that if we hope to promote a more scientifically literate citizenry and to attract and educate the Nation's future scientists and engineers, we cannot depend upon schools alone. Instead, we should be tapping all our resources and looking at the potential for learning that happens every day, outside the classroom door.

I want to thank all of the witnesses for taking the time to appear before the Committee this morning and I look forward to your testimony.

[The prepared statement of Chair Lipinski follows:]

PREPARED STATEMENT OF CHAIR DANIEL LIPINSKI

Good morning and welcome to this Research and Science Education Subcommittee hearing on informal Science, technology, engineering, and math (or STEM) education.

While we often examine and discuss ways to improve STEM education in the classroom, we rarely look at the many opportunities for learning elsewhere. A great deal of learning happens throughout our lives in everyday activities—from having a conversation at the family dinner table or watching a show on television, to attending a summer camp at a zoo or taking a trip to a museum. Not just students but the general public are exposed to opportunities for science learning through informal education every day. Today we will explore the ways in which informal learning institutions are uniquely positioned to attract and educate the public about STEM issues, as well as the role of informal institutions in contributing to and enhancing formal classroom learning.

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I believe that if we hope to promote a more scientifically literate citizenry, and to attract and educate the Nation's future scientists and engineers, we cannot depend upon schools alone. Instead, we should be tapping all our resources and looking at the potential for learning that happens every day outside the classroom door. I want to thank all of the witnesses for taking the time to appear before the Committee this morning and I look forward to your testimony.

Chair LIPINSKI. The Chair now recognizes Mr. Ehlers for an opening statement.

Mr. EHLERS. Thank you, Mr. Chair, and I am sure we will have a lot of good opportunities to work together, and we share a great

number of common interests, not just including science but also many aspects of teaching science. So we are going to have a good year here.

I am intrigued about this hearing on informal science education. I never knew the term, even though that is how I learned science for my first 12 years of school. As a child, I was both unfortunate and fortunate. I was unfortunate to have a serious enough disease I couldn't go to school but fortunate enough that I was well enough to study at home where actually I learned more than I would have at school. Don't tell that to my former teachers. But I would get the assignments every week, and I would plough through them. But no experiments in science. My sister, fortunately, was in a high school where they gave—she was taking a science class, I think chemistry, where they gave free copies of *Popular Science*, and she brought those home and I devoured those. And I still remember one of my first striking home experiments which was informal science education. I lit a candle, took some bicarbonate of soda, mixed it in a glass, formed a little trough of paper, and held it near the candle and proceeded to pour. Nothing that you could see, and the carbon dioxide went down the trough and extinguished the candle. That was just amazing to me, that something I couldn't see, touch, feel, smell, could actually exist, could move, and could put out a fire. That is the sort of thing that you never forget, particularly if you develop them yourself, and I did the same thing with some of my high school work.

The informal science education takes place almost everywhere but in the classroom, and I was fortunate that I had parents who could answer my questions quite often or would help me find the answer, to be a more proper way of saying it. But the question is, how do we measure the results of it? How do we know whether it is good informal education or not? How does it fit into the whole of educating the child about the wonders of science? And above all, how does it get them interested in science?

Informal science education then can take place almost anywhere but in the classroom. A recent report from the National Academies on this topic highlights the difficulty in assessing the impacts of non-classroom learning on science knowledge, attitudes, and actions. And maybe you have to wait 40 years to see whether the students learn enough science to get a Ph.D. in physics and become a Member of Congress. I don't know if I am one of the data points on their charts or not. Clearly, formalized science, technology, engineering, and math, which we call STEM education can only go so far. Informal experiences shape how people view science and can help people get comfortable enough with science to spend their free time in places like parks, museums, and after-school activities. And also, a real advantage of the informal education is getting kids really excited about it because they are part of the discovery process which they often are not in a traditional classroom. Informal science education has a unique platform to engage the public in science in ways that show it is not only fun but also fundamental to the competitiveness of our country. These opportunities also reach many students and families who may not have received a high-quality STEM education through traditional classroom experi-

ences or who may have been turned off to science by earlier negative experiences.

One challenge faced by the informal science education community, and policy-makers, is that inherently minimally-structured environments do not lend themselves to evaluation. I am particularly interested in how the federal agencies can support the necessary research and provide resources to informal practitioners about how to develop and manage successful programs.

I look forward to hearing from our witnesses today. I certainly appreciate your attendance here and look forward to this being another informal learning experience. Thank you very much.

[The prepared statement of Mr. Ehlers follows:]

PREPARED STATEMENT OF REPRESENTATIVE VERNON J. EHLERS

Today's hearing is an opportunity to learn about the blossoming field of informal science education and research.

Informal science education takes place almost everywhere but in the classroom. The recent report from the National Academies on this topic highlights the difficulty in assessing the impacts of non-classroom learning on science knowledge, attitudes and actions. Clearly, formalized science, technology, engineering and math (STEM) education can only go so far. Informal experiences shape how people view science and can help people get comfortable enough with science to want to spend their free time in places like parks, museums, and after-school activities. Informal science education has a unique platform to engage the public in science in ways that show it is not only fun, but also fundamental to the competitiveness of our country. These opportunities also reach many students and families who may not have received a high-quality STEM education through traditional classroom experiences or who have been turned off to science by earlier negative experiences.

One challenge faced by the informal science education community—and policy-makers—is that inherently minimally-structured environments do not lend themselves to evaluation. I am particularly interested in how the federal agencies can support the necessary research and provide resources to informal practitioners about how to develop and manage successful programs.

I look forward to hearing from our witnesses today. Thank you for your attendance.

Chair LIPINSKI. If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Carnahan follows:]

PREPARED STATEMENT OF REPRESENTATIVE RUSS CARNAHAN

Mr. Chairman, thank you for hosting this hearing to examine the role of informal environments in STEM education.

As we have all mentioned time and again, the *Rising Above the Gathering Storm* report provided us with both the knowledge that our nation's standing as the global leader in the STEM field is at risk as well as solid tools for policy-makers to counteract this worrisome trend. We must address this issue with all available resources, both formal and informal.

The National Academies Committee report showed that there is ample evidence to suggest that science learning takes place throughout the life span and across venues in non-school settings. In my home district of St. Louis, the Missouri Botanical Garden offers a great example of one such informal science learning environment. In their Power of Plants Contest, students pick a plant that does great things for people and tell its story through a two- or three-dimensional work of art.

Programs like this provide opportunities to reach into schools or formal environments and allow students to connect in an informal basis. These informal experiences can provide opportunities to form personal connections which can be much stronger compared to those in a formal classroom setting. It is these experiences that can lead to self-directed learning which leave a strong and lasting impression on students.

I am pleased that today's hearing again focuses on the important task of ensuring that our STEM programs are working not only in the classroom, but beyond as well.

To all the witnesses before us today—thank you for taking time out of your busy schedules to appear before us today. I look forward to hearing your testimony.

Chair LIPINSKI. I would like to also welcome Mr. Griffith here as a freshman. It is good to have you here on this subcommittee.

Mr. GRIFFITH. Thank you, Mr. Chair.

Chair LIPINSKI. I look forward to what you add to our subcommittee, and I just want everyone to know that these are very important issues that we are working on here in the Subcommittee, very important for the future of our country. And we are open to any ideas that anyone has on this subcommittee about what we might want to talk about, what we might want to work on during this Congress.

At this time I want to introduce our witnesses. We will start with Dr. Joan Ferrini-Mundy, the Director of the Division of Research on Learning in Formal and Informal Settings in the Education and Human Resources Directorate, of the National Science Foundation. Dr. Phillip Bell is the Co-Chair of the National Academies report, *“Learning Science in Informal Environments: People, Places, and Pursuits”* and a professor at the College of Education at the University of Washington, Seattle. Ms. Andrea Ingram is the Vice President of Education and Guest Experiences at the Museum of Science and Industry, Chicago. And later on I may have the opportunity to regale everyone with my memories of being a kid and going to the museum. Mr. Robert Lippincott is the Senior Vice President for Education at The Public Broadcasting Service. I am not sure I am going to talk about watching the TV when I was a kid, but I certainly watched a lot of PBS. Finally, I am pleased to introduce Dr. Alejandro Grajal from my district, just west of Chicago. He is the Senior Vice President of Conservation, Education, and Training at the Chicago Zoological Society which is the organization that operates the Brookfield Zoo.

Now, as our witnesses should know, spoken testimony is limited to five minutes each, after which the Members of the Committee will have five minutes each to ask questions. And we will have time, I am sure certainly during the questions, if there is anything that you want to add onto your five minutes. And you know, time permitting, we may have time for a little bit of wrap-up at the end. So if you could limit yourselves to the five minutes in any opening statements.

So we will start with Dr. Ferrini-Mundy.

STATEMENT OF DR. JOAN FERRINI-MUNDY, DIRECTOR, DIVISION OF RESEARCH ON LEARNING IN FORMAL AND INFORMAL SETTINGS, DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES, NATIONAL SCIENCE FOUNDATION

Dr. FERRINI-MUNDY. Chairman Lipinski, Ranking Member Ehlers, and distinguished members of the Subcommittee, I am Joan Ferrini-Mundy, Director of the Division of Research on Learning in Formal and Informal Settings at the National Science Foundation in the Directorate for Education and Human Resources. Thank you for the opportunity to testify about informal education in science, technology, engineering and mathematics, the STEM disciplines. Mr. Chairman, I ask that my written statements be

made a part of the record, and I would like to summarize my remarks.

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 in assessment; and the significance of informal learning environments for broadening participation in STEM disciplines.

Our signature catalyst program for investment in this area is the Informal Science Education (ISE) program, whose primary goals are to promote lifelong learning of science, technology, engineering, and mathematics by the public and to advance the knowledge base and human capacity for improving informal STEM education.

There currently are about 200 funded projects in the ISE portfolio. Roughly 35 percent of the awards are to institutions of higher education, and the remaining 65 percent are disbursed among museums, science centers, youth and community programs, and radio, television, multi-media and web producers. The average ISE budget over the past five years has been about \$62.9 million. As hosts of new scientific findings and STEM issues of importance to the public emerge daily, it is essential to have a robust body of research and evaluation that maximizes the potential impact of our investments in informal science education.

We need to know much more about how to motivate and interest learners in STEM topics, about what science topics lend themselves best to learning in informal settings, about how learning in informal settings can broaden participation in STEM careers, and about how to engage citizens with the science that affects public policy as well as their daily lives.

The recent study, *Learning Science in Informal Environments*, the report of the National Research Council of the National Academies, was funded by the ISE program. It provides a synthesis of the research literature on learning in informal environments, and the report confirms that everyday experiences can support science learning for virtually all people.

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 being learned about science in such settings and what science is being learned, it is important to determine what will engage the learners and hold their attention, and that is a crucial topic for researchers.

There are major challenges in this research domain. What outcomes should be expected in informal learning environments and what assessments are best for measuring them? Museum-goers don't expect to take a formal test after a casual visit. The experiences are often brief and fragmented, so it may not be reasonable to expect depth of content learning from a single exposure.

Researchers are studying such outcomes as attitude, awareness, interest, and behavior. Their methods include self-report, recording visitors' conversations, interviews, and the timing and tracking studies of behaviors. There is a continued need for valid and reliable instruments and measures to assess the appropriate outcomes of learning in informal settings. NSF-funded researchers are addressing these challenges through the ISE program and others.

I find that there is enthusiasm across NSF about sharing exciting science with diverse audiences through informal learning opportunities. We recognize the great potential of these venues for engaging youth who may not thrive in the formal education system. Some ISE projects focus specifically on learners from groups traditionally under-represented in STEM, and most projects include outreach to these groups. The focus on broadening participation extends well beyond EHR. In the Directorate for Geosciences, for example, there is a project that prepares teachers in urban settings to integrate the resources of their city into their STEM teaching. In the Directorate for Computer and Information Science and Engineering, a project with the Boys and Girls Clubs of America uses culturally responsive approaches to attract and retain high school students in computer science.

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 informal science education environments. The portfolio is increasingly robust in the area of research about learning in informal settings. Through programs in the Division of Research on Learning, we plan to continue encouraging and supporting scientific discovery in informal science education.

I would like to thank the Subcommittee for this opportunity to share with you information about investments made by the NSF in this area. Mr. Chair, this concludes my remarks. I would be happy to answer any questions.

The prepared statement of Dr. Ferrini-Mundy follows:]

PREPARED STATEMENT OF JOAN FERRINI-MUNDY

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

¹National 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.

relatively small compared to the time 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 percent), academic institutions (24.1 percent), media producers and television stations (20.8 percent), 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 percent 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 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):

<i>FY 2004</i>	<i>FY 2005</i>	<i>FY 2006</i>	<i>FY 2007</i>	<i>FY 2008</i>
\$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 Exhi-

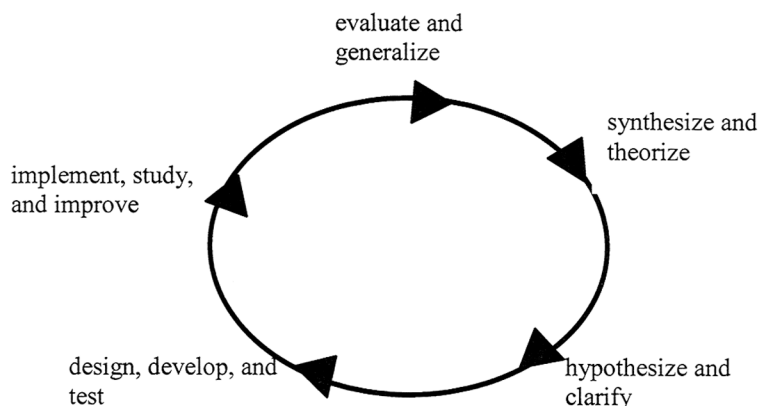
²National Science Board Commission on Precollege Education in Mathematics, Science and Technology, *Educating Americans for the 21st Century* (Washington, DC: National Science Foundation, 1983, CPCE–NSF–04).

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

bition, 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 percent.

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 Center for Advancement of Informal Science Education (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 percent 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 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 \$7M, 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 cru-

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)

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

cial 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 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"—museumgoers 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 under-represented 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 under-represented 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 oppor-

tunities as a resource for broadening participation in STEM fields and make investments to advance this potential.

I have already mentioned the Innovative Technology Education Experiences for Students and Teachers (ITEEST) 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 under-represented 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 under-represented 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, websites 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 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.

BIOGRAPHY FOR JOAN FERRINI-MUNDY

Dr. Joan Ferrini-Mundy is the Director of the National Science Foundation’s (NSF) Division of Research on Learning in Formal and Informal Settings (DRL), in the Directorate for Education and Human Resources (EHR). DRL programs invest

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

in research and development efforts to support the learning of science, technology, engineering and mathematics at all levels and in all settings. She has recently been appointed Executive Officer (Acting) of the Directorate for Education and Human Resources. She serves as an NSF representative on the Education Subcommittee of the National Science and Technology Council, and represents EHR on NSF's Facilitating Transformative and Interdisciplinary Research Working Group. While at NSF Dr. Ferrini-Mundy holds a faculty position at Michigan State University where she is a University Distinguished Professor in Mathematics Education and Assistant Vice President for STEM Education and Policy. Her research interests include calculus teaching and learning, the development and assessment of teachers' mathematical knowledge for teaching, and the improvement of student learning in K-12 mathematics and science. Dr. Ferrini-Mundy has served on the National Council of Teachers of Mathematics' Board of Directors, The Board of Governors of the Mathematical Association of America, and as Director of the National Research Council's Mathematical Sciences Education Board. She also participated as an Ex Officio Member of the National Mathematics Advisory Panel in 2007-2008, and serving as Co-Chair of the Instructional Practices Task Group.

Chair LIPINSKI. Thank you very much for your testimony. Dr. Bell.

STATEMENT OF DR. PHILIP BELL, THE GEDA AND PHIL CONDIT PROFESSOR OF SCIENCE AND MATH EDUCATION, ASSOCIATE PROFESSOR OF THE LEARNING SCIENCES; DIRECTOR, INSTITUTE FOR SCIENCE AND MATHEMATICS EDUCATION, UNIVERSITY OF WASHINGTON, SEATTLE; CO-CHAIR, COMMITTEE ON LEARNING SCIENCE IN INFORMAL ENVIRONMENTS, BOARD ON SCIENCE EDUCATION, NATIONAL ACADEMY OF SCIENCES, THE NATIONAL ACADEMIES

Dr. BELL. Good morning, Mr. Chairman, and Members of the Subcommittee. Thank you for the opportunity to appear before you today. I am Philip Bell from the University of Washington. I served as Co-Chair of the Committee on Learning Science in Informal Environments of the National Research Council, and I ask that my written remarks be made part of the record of the hearing.

I was asked to describe the work in my research group and summarize the conclusions and recommendations of the recent NRC consensus study. I participate in a large-scale interdisciplinary research effort called the Learning in Informal and Formal Environments Center, or LIFE Center, a collaboration of the University of Washington, Stanford University, SRI International. It is funded through NSF's Science of Learning Center program within the SBE Directorate.

In LIFE we study the social foundation of how people learn across a broad range of learning environments from the classrooms, science centers, aquaria, and zoos to after-school programs, Internet sites, video game environments and in the midst of family life. My research group investigates how youth and families from multicultural urban communities develop science and technology-related expertise across different settings. In our research, we found a surprising and troubling pattern where children pursue and engage in sophisticated STEM learning outside of school, but those interests and early competencies are not recognized or built upon in the classroom.

Just one example, we followed an elementary school-aged boy for several years documenting his learning across settings who developed significant expertise related to mechanical engineering, from building robotic kits at home to engaging in complex puzzle activity

on the science center floor, but in the classroom, he is not perceived as being interested in academic subjects at all. Such disconnects in learning between home and school are putting these particular children at higher risk of academic failure in STEM.

Our research further indicates that STEM academic achievement, although crucial, is only part of what is needed to cultivate expertise in STEM, and people's activities in informal environments are an equally crucial platform for learning, as we are hearing from Congressman Ehlers.

Efforts to enhance the scientific capacity of society typically focuses on formal schooling. LIFE Center researchers developed the diagram shown over on the easel there to my left, to your right, to characterize roughly the amount of time individuals spend in formal and informal environments, with lifelong learning along the horizontal and life-wide learning as people go across settings along the vertical.

What is often overlooked or underestimated is the potential of STEM learning in non-school settings. Each year tens of millions of Americans young and old explore and learn about science by visiting informal learning institutions, participating in programs, and countless more use media to pursue their science-related interests. From a lifelong, life-wide perspective, it is imperative that we leverage informal learning environments to support workforce development, civic participation, and STEM-related policy issues, and to promote scientific literacy among the citizenry.

The Informal Science Education program, as we already heard, funded a consensus study with the Board on Science Education at the NRC with the goal of synthesizing the existing research about how people learn in informal environments. The interdisciplinary committee that was convened organized its analysis by looking at the various places where science learning occurs. These included everyday experiences like hiking at a national park with your family, pursuing a hobby or learning on the farm, as well as designed settings, such as visiting a science center, zoo, aquarium, or botanical garden or participating in educational programming, such as summer science programs for youth, environmental monitoring experiences for citizens, or Elderhostel programs that are related to science. The committee found abundant evidence that informal learning environments routinely support significant science learning for individuals from all ages, from a broad variety of backgrounds and ways that uniquely serve their personal and professional interest and that relate to the broader STEM interest of society.

However, the field is lacking a clear statement of goals that are appropriate for these settings, learning goals, which can be measured. The committee developed and used the strands of science learning framework that articulates science specific capabilities supported by informal learning environments. The six interrelated strands reflect the field's commitment to getting learners to participate and connect to science in stimulating, interactive, contemporary, and personally relevant ways.

In closing, I want to mention some high priority policy issues that are described in the report. First, in terms of broadening participation in STEM, studies do suggest that informal learning envi-

ronments may be particularly effective for youth from historically non-dominant communities. However, there is variability in the success of these environments in attracting and engaging diverse audiences. We believe that a better understanding of the naturally occurring science learning in a diverse range of communities is needed to inform basic theory about how people learn as well as to design informal learning experiences that actually are tailored to these communities.

Secondly, we believe that there should be sustained support for high-quality informal programs and experiences that focus on STEM. Informal learning environments represent a crucial part of society's infrastructure for STEM education.

Thirdly, although it is important to understand the impact of informal environments, a more important question may be how science learning occurs across a range of formal and informal environments. The science learning literatures and fields are segmented in ways that are at odds with how people routinely traverse settings and can engage in learning across those settings day to day.

Thank you for the opportunity to be here, and I look forward to your questions.

[The prepared statement of Dr. Bell follows:]

PREPARED STATEMENT OF PHILIP BELL

Good morning, Mr. Chairman and Members of the Committee. Thank you for the opportunity to appear before you today to discuss informal STEM education in science. I am Philip Bell, Associate Professor of Learning Sciences in the College of Education at the University of Washington. I served as a Co-Chair of the Committee on Learning Science in Informal Environments of the National Research Council (NRC), the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies.

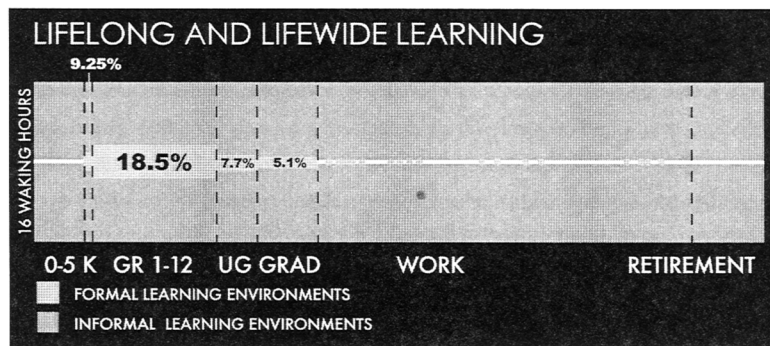
In the following statement I will briefly describe what research tells us about how and why people learn science in informal environments, what role informal environments can play in broadening participation in STEM fields, and what priorities exist for research and evaluation related to informal science education. Let me start by stating that a synthesis of the research clearly indicates that informal learning environments represent a crucial part of our society's educational infrastructure for STEM education. *Informal learning environments routinely support significant science learning for individuals of all ages from a broad variety of backgrounds in ways that uniquely serve their personal and professional interests—and the broader STEM-related interests of society as well.* At the same time, additional research is needed to better understand the cumulative effects of how people learn across formal and informal learning environments, to better understand the influence of contemporary media on science learning, and to document how people from groups that are under-represented in STEM fields learn science, which we take to be both a basic and applied area of research. These inquiries can provide critical information for developing better programs and experiences for learners.

I was asked to describe the work of my research group at the University of Washington and to summarize the conclusions and recommendations of the recent NRC consensus study on *Learning Science in Informal Environments*. Let me start with the research of my group as I think it sets the stage for summarizing the report. Over the past five years the National Science Foundation has been supporting six large-scale, long-term research centers around the country through the Science of Learning Center program focused on advancing the frontiers of the sciences of learning through integrated, interdisciplinary research. I participate on the faculty leadership team of one such center called the Learning in Informal and Formal Environments Center—or the LIFE Center—which is a collaboration primarily among researchers at the University of Washington, Stanford University, and SRI International. The scientific mission of the LIFE Center (<http://life-slc.org/>) is to document the social foundations of how people learn across formal and informal learning environments using cognitive, social and cultural, neurobiological, and developmental perspectives on learning.

LIFE has a portfolio of research studies that investigate STEM learning—including how families engage in math learning in everyday activities like personal finance and health decisions, how youth develop expertise about technology, and how young girls and boys develop stereotypes about academic subjects like math and reading. We do that work across a broad range of venues for learning—from classrooms, science centers, aquaria, and zoos to after-school programs, Internet sites, virtual spaces, hobby groups, and in the midst of family life. My research group investigates how youth and their families develop science and technology related expertise across a broad range of formal and informal environments, groups, and activities in their lives. We construct finely detailed cultural and ecological accounts of where, how, why, what, and with whom children learn over years with special attention to knowledge and expertise that has real consequences for the youth and families in our studies. We also conduct extended multi-week curriculum design studies in elementary science classrooms in collaboration with teachers to test theoretical questions about how we can bridge what the children learn and do at home with what they are learning at school. The fieldwork generates principles of learning that inform educational design principles that are tested in the context of classroom instruction.

Our research takes place within multicultural, urban communities, and we are strongly focused on understanding how to broaden participation in STEM learning and activities. As we document how children learn across different settings, we have found a surprising and troubling pattern where children pursue and engage in sophisticated STEM learning outside of school but where those interests and early competencies are not recognized or built upon in the classroom. Just as one example: we followed an elementary school-aged boy with significant expertise with mechanical systems—from building robotic kits at home and designing solutions to complex puzzles at a science center—who, at school, was perceived as not being interested in academic subjects. Such disconnects in learning between home and school are putting these particular children at a higher risk of academic failure in STEM. At the same time, many of the cases document how interest, personal identification with STEM endeavors, and practice with the tools of STEM disciplines are sustained in important activities happening outside of school—while in summer programs at science centers and in collaborative activities with peers and parents. That is, *STEM academic achievement in school, although crucial, is only part of what is needed to cultivate personal expertise in STEM—and the activities with which people engage in informal learning environments are an equally crucial platform for STEM learning. This point highlights the truly complementary role of schooling and informal learning environments in STEM learning.*

Researchers in the LIFE center developed the following diagram to roughly characterize the amount of time individuals spend in formal and informal learning environments. The diagram highlights changes in this split between formal and informal learning environments over the life course of the individual—what we call *life-long learning*—and it gives a sense of the breadth of different social settings in which people spend time in daily life—what we refer to as *life-wide learning*. As it indicates, the majority of our time is spent within the range of informal learning environments in which we participate—in the “sea of blue” as we call it.



The knowledge and practices of science shape people's lives in fundamental ways. It is increasingly understood that the science and technology enterprise plays a crucial role in our economy as well as in our communities and in our personal lives. This makes it imperative that we leverage informal learning to support workforce development, civic participation in STEM issues and policy, and to promote scientific literacy among all citizens.

Efforts to enhance the scientific capacity of society typically target schools and focus on such strategies as improving science curriculum and teacher quality and strengthening the STEM pipeline. What is often overlooked or underestimated is the potential for science learning in non-school settings, where people actually spend the majority of their time.

Beyond the schoolhouse door, opportunities for science learning abound. Each year, tens of millions of Americans, young and old, explore and learn about science by visiting informal learning institutions, participating in programs, and using media to pursue their interests. Thousands of organizations dedicate themselves to developing, documenting, and improving science learning in informal environments for learners of *all* ages and backgrounds. Countless others choose to learn about science topics in ways that serve their interests or needs and engage in science-related hobbies with others who share their interests. So, if we ask the crucial question: Where do people learn science? The answer is *everywhere*—in ways that we only partially understand.

The National Science Foundation funded a consensus study through their Informal Science Education program with the Board on Science Education at the National Research Council with the goal of synthesizing the existing research about how people learn science in informal environments. The Board on Science Education at the NRC is an advisor to the Nation on all issues of science education and oversaw the project. In response, the Committee on Science Learning in Informal Environments was established to examine the potential of non-school settings for science learning. The committee, comprised of 14 experts in science, education, psychology, media, and informal education, conducted a broad review of the literatures that inform learning science in informal environments. The charge we were given specifically included assessing the evidence of science learning across settings, for different age groups, and over different time frames. We were asked to identify the qualities of learning experiences that are unique to informal environments and to explore the relationship between the science learning that happens in informal environments and the learning that goes on within school. And we were also asked to develop an agenda for research and development related to how and why people learn science in informal environments.

The committee organized its analysis by looking at the places where science learning occurs as well as cross-cutting features of informal learning environments. The “places” that we considered included: *everyday experiences*—like hiking, pursuing a hobby, or farming; *designed settings*—such as visiting a science center, zoo, aquarium, botanical garden, planetarium; and *educational programs*—such as after-school or summer science programs for youth, environmental monitoring experiences for citizens, or Elderhostel and senior center programs for elders. We also examined cross-cutting features that shape informal environments including: *the role of media* as a context and tool for learning and the opportunities these environments provide for *broadening participation in STEM* for individuals from diverse communities that are historically under-represented in STEM fields.

A critical missing piece in this area of research and development is a clear statement of goals that are appropriate for these settings and which can be measured. The committee developed and used a “strands of science learning” framework that articulates science-specific capabilities supported by informal environments. It builds on the framework developed for K–8 science learning in the NRC *Taking Science to School* report from 2007. The six strands illustrate how schools and informal environments can support complementary educational goals, and serve as a tool for organizing and assessing science learning. The six interrelated aspects of science learning covered by the strands reflect the field's commitment to getting learners to participate and connect to science as a stimulating, creative, and personally relevant endeavor.

Our efforts to improve STEM education frequently focus on the importance of the disciplinary content of science and how people come to understand scientific concepts, principles, and established facts. The committee agreed that the knowledge of science is an important outcome of science learning, but there is more to the learning of science than understanding content. The other five strands help bring a more complete image of learning into view. These broader dimensions of science learning are necessary for developing interest in young learners. For example, early interest in science is clearly associated with entry into STEM fields. In this vein,

it is also crucial for people to develop science-related interests and to experience enjoyment, to come to identify with science, to know how to develop and evaluate scientific arguments and explanations of natural phenomena, to know how scientists actually inquire and build new knowledge using specialized tools and equipment, and to understand the multifaceted role of the institution of science in society.

The six science learning strands help us understand how learners in informal environments:

Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.

Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models and facts related to science.

Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.

Strand 4: Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.

Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.

Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

With this multi-dimensional definition of science learning, we then explored the question: What is the contribution of informal environments towards these outcomes? The report describes the state of our knowledge about how the strands of science learning are supported across the different informal learning environments. For example, educational television and museum experiences can support conceptual learning. Family conversations can help children learn to produce scientific conversations. After-school programs can give learners access to learning to use the specialized tools of science and support the learning of science content. Prior knowledge, interest, and identity—long understood as integral to the learning process—are especially important in informal learning environments, where opportunities to learn can be fleeting, episodic, and strongly learner-driven. At any point in the life span, learners have knowledge and interests, which—given opportunities and support—they can develop into for further science learning. This includes their comfort and familiarity with science. Although learners' knowledge may remain tacit and may not always be scientifically accurate, it can serve as the basis for more sophisticated learning over time. Educators can support learners of all ages by intentionally querying, drawing on, and extending their interests, ideas about self, and knowledge.

So, do people learn science in non-school settings? This is a critical question for policy makers, practitioners, and researchers alike—and the answer is yes. The committee found abundant evidence that across all venues—everyday experiences, designed settings, and educational programs—individuals of all ages learn science in significant ways. We know from vast literatures in the science of learning field on cognition and development that sophisticated learning only results from concerted effort and sustained practice. It is crucial for us to recognize and understand how such learning and expertise gets supported and cultivated across the settings and pursuits in a person's life. Understanding the cumulative effects of STEM learning as it occurs across formal and informal learning environments is a high-priority area for future research.

Virtually all people of all ages and backgrounds engage in informal science learning in the course of daily life. Informal environments can stimulate science interest, build learners' scientific knowledge and skill, and—perhaps most importantly—help people learn to be more comfortable and confident in their relationship with science. Researchers and educators interested in informal settings are typically committed to open participation in science: building and understanding science learning experiences that render science accessible to a broad range of learners and in ways that serve their interests.

Everyday experiences can support science learning for virtually all people in response to the interests and needs that matter most to them—including environmental risks, health decisions, and appreciation of the natural world. If educators can attend more deeply to the ways in which people already intersect with science and technology in their lives then our educational efforts will be more powerful and meaningful.

Designed spaces—including museums, science centers, zoos, aquariums, botanical gardens, and environmental centers—can also support science learning. Rich with real-world phenomena and unique learning experiences, these are places where peo-

ple can pursue and develop science interests, engage in science inquiry, and reflect on their experiences through sense-making conversations.

Educational programs focused on science learning take place in schools and community-based and science-rich organizations and include sustained, self-organized activities of science enthusiasts. Such programs are growing in number, with the support of significant federal funding, and there is mounting evidence that structured, non-school science programs can feed or stimulate the science-specific interests of adults and children, may positively influence academic achievement for students, and may expand participants' sense of future science career options.

Science media, in the form of radio, television, the Internet, and hand-held devices, are increasingly pervasive and make science information increasingly available to people across venues for science learning. Science media, especially interactive forms that are web-based, are fundamentally changing people's engagement with science and offer new ways to support science learning. Although the evidence is strong for the impact of educational television on science learning, substantially less empirical evidence exists on the impact of other media—digital media, gaming, radio—on science learning specifically. There is good reason to believe that such media are increasingly supporting science learning, but we need more research focused on how and why people learn science specifically through interactive and social media.

What role can informal learning environments play in broadening participation and promoting diversity in STEM fields? A report on diversity and learning recently edited Professor James Banks from the University of Washington states: "Being born into a racial majority group with high levels of economic and social resources—or into a group that has historically been marginalized with low levels of economic and social resources—results in very different lived experiences that include unequal learning opportunities, challenges, and potential risks for learning and development."

The committee recognized that there is increasing interest in the informal learning research and practitioner fields for understanding cultural variability among learners and its implications: how learners participate in science in relation to the values, attitudes, histories, and practices of their communities and those of science.

Studies suggest that informal environments for science learning may be particularly effective for youth from historically non-dominant groups—groups with limited social and political status in society who are often marginalized in educational experiences. For example, evaluations of museum-based and after-school programs suggest that these experiences can support academic gains for children and youth from historically non-dominant groups. These successes often draw on local issues and the prior interests of participants—for instance, by integrating science learning and service to the community. Similarly, case studies of community science programs targeting participation of youth from historically non-dominant groups—such as children in Native American or recent immigrant communities—document participants' sustained, sophisticated engagement with science and sustained influence on school science course selection and career choices. In these programs, children and youth play an active role in shaping the subject and process of inquiry, which may include local health or environmental issues about which they subsequently educate the community. Equally interesting in these contexts is the cross-generational learning—the ways in which informal learning opportunities help connect children, parents, grandparents, and other community elders.

Many designers in informal science learning are making efforts to address inequity and wish to partner with members of diverse communities. Effective strategies for organizing partnerships include identifying shared goals; designing experiences around issues of local relevance; taking the everyday patterns of participation of learners into account; and designing experiences that satisfy the values and norms and reflect the practices of all partners. These efforts merit replication and further study, including analysis of how science-rich institutions can collaborate with and serve community-based organizations and how these programs support and sustain participants' engagement.

To understand whether, how, or when learning occurs, good outcome measures are necessary, yet efforts to define outcomes for science learning in informal settings have often been controversial. At times, researchers and practitioners have adopted the same tools and measures of achievement used in school settings. In some instances, public and private funding for informal education has even required such academic achievement measures. Yet traditional academic achievement outcomes are limited. Although they may facilitate coordination between informal environments and schools, they fail to reflect the defining characteristics of informal environments in three ways. Many academic achievement outcomes (1) do not encompass the range of capabilities that informal settings can promote; (2) violate critical

assumptions about these settings, such as their focus on leisure-based or voluntary experiences and non-standardized curriculum; and (3) are not designed for the breadth of participants, many of whom are not K–12 students.

The challenge of developing clear and reasonable goals for learning science in informal environments is compounded by the real or perceived encroachment of a school agenda on such settings. This has led some to eschew formalized outcomes altogether and to embrace learner-defined outcomes instead. The committee's view is that it is unproductive to blindly adopt either purely academic goals or purely subjective learning goals. Instead, the committee prefers a third course that combines a variety of specialized science learning goals used in research and practice—for example, the six strands of science learning developed in the report.

In closing, the following are some high-priority policy considerations related to research on the role of informal learning environments in STEM education:

- There should be sustained support for high-quality informal programs and experiences that focus on STEM, whether they occur in museums, aquaria, zoos, science and technology centers, botanical gardens, in out-of-school program settings or other informal efforts. Significant and unique science learning occur in these venues—in ways that can be leveraged to support school-based academic outcomes and in ways that represent important experiences with STEM disciplinary fields as an end in and of themselves. The report offers guidance for how these activities should be evaluated and studied so that we can gain a better understanding of how and when they succeed.
- Although it is important to understand the impact of informal environments, a more important question may be how science learning occurs across the range of formal and informal environments. The science learning literatures and fields are segmented (e.g., into school learning, informal education) in ways that are at odds with how people routinely traverse settings and can engage in learning activities across settings. Thus, research should attempt to explore learners' longer-term, cross-cutting (or "life-wide") learning experiences. Further work should increase understanding of the connections or barriers in learning between more formal and more informal science learning environments. These inquiries can provide critical information for developing better programs and experiences for learners.
- Media, in particular television and Internet resources, are the most sought-out tool for learning about science. Through various forms of digital media—blogs, virtual spaces, wikis, serious games, RSS feeds, etc.—access to scientific ideas and information and knowledgeable others has become, if not pervasive, at least widespread. Arguments about the transformative power of media for informal science learning are based on very modest evidence and warrant further investigation. Research on the impact of media is needed to understand how the unique features of media can support different aspects of science learning (e.g., the six strands).
- The committee concluded that informal learning environments may be particularly important for science learning for diverse groups. Research exists on how specific groups can come to participate in specific venues, but questions remain about how to best empower science learning for diverse groups through informal learning environments. There is variability in the success of these environments in attracting and engaging diverse audiences. We believe that a better understanding of the naturally occurring science learning in historically non-dominant and dominant cultures is needed to inform basic theory about learning and to inform the design of learning experiences that meaningfully attend to the cultural practices of diverse communities.

Thank you for the opportunity to present to the Subcommittee on this important set of topics. I look forward to your questions and comments.

BIOGRAPHY FOR PHILIP BELL

Philip Bell pursues a cognitive and cultural program of research across diverse environments focused on how people learn in ways that are personally consequential to them. He is an associate professor of the Learning Sciences at the University of Washington and the Geda and Phil Condit Professor of Science and Mathematics Education, and he directs the ethnographic and design-based research of the Everyday Science and Technology Group (<http://everydaycognition.org>). He also directs the University of Washington Institute for Science and Mathematics Education focused on coordinating P–20 education efforts across the University. Bell has studied everyday expertise and cognition in science and health, the design and use of novel

learning technologies in science classrooms, children's argumentation, culturally responsive science instruction, the use of emerging digital technologies within youth culture, and new approaches to inquiry instruction in science. He is a Co-Lead of the Learning in Informal and Formal Environments (LIFE) Center (<http://life-slc.org/>) and is a Co-PI of COSEE–Ocean Learning Communities (<http://cosee-olc.org/>). Bell serves as a member of the Board on Science Education with the National Academy of Sciences and co-chairs the National Research Council Consensus Committee on Learning Science in Informal Environments. He has a background in human cognition and development, science education, computer science, and electrical engineering.

Chair LIPINSKI. Thank you, Dr. Bell, and Ms. Ingram.

**STATEMENT OF MS. ANDREA J. INGRAM, VICE PRESIDENT,
EDUCATION AND GUEST SERVICES, MUSEUM OF SCIENCE
AND INDUSTRY, CHICAGO**

Ms. INGRAM. Thank you, Chairman, and Members of the Subcommittee, and thank you for inviting us here today to speak with you. I would also like to thank NSF and Dr. Bell and his co-authors for investing their time and thoughtfulness in producing this report that is so important. It informs our efforts.

As you know, which is why we are here, science and technology are critically important to human well-being, economic growth and a sustainable environment. America's social and economic future depends on new generations of scientists who can help sustain our legacy of innovation and science leadership.

Our schools cannot do this alone. Wonderful, inspirational and important resources exist outside of the classroom in our national laboratories and our universities and our museums, in our zoos, and in our libraries.

If we share the objective of supporting science achievement to create our next generation of innovators, then we must ensure that these resources are well-aligned to support the engagement and excellence of our youth in science. When we adopt this shared objective, the lines distinguishing between formal and informal education become blurred and lose relevance. What we have are a variety of learning strategies and a variety of tools all targeted to ensure broad access, opportunity and success in the sciences.

At the Museum of Science and Industry in Chicago, we have embraced this shared objective and have designed our historic transformation to reflect this new direction. We are unified in our commitment as an institution to become an esteemed educational institution that will play a critical role in the advancement of science education. And with that recognition, we have adopted the vision to inspire and motivate children to achieve their full potential in the fields of science, technology, medicine, and engineering. And in doing so, we have recognized that in order to overcome this quiet crisis in our scientists and engineers in the United States, we must diversify and broaden those who are engaged and inspired into careers in the sciences.

So in adopting that vision and taking this new direction, that means that we have changed our practices in the designs of our exhibits and how we extend the reach of those exhibitions through programming, and in our view, of our collaborative leadership role. In our exhibitions, we have intentionally adopted an integrated approach in which our education teams participate in our exhibit design process to ensure that the content embedded in the exhibitions

is aligned with national, international, and local learning standards and objectives so that they can be broadly used as tools to enhance science achievement in the classroom. We have reflected on and embedded the Atlas of Science Literacy created by the American Association for the Advancement of Science, Project 2061, and in doing so, our tools will become world-class instruments to advance science education.

Through our Center for the Advancement of Science Education, which we have newly formed as part of this transformation, we extend the content of our exhibitions to where our guests and youth are. That means that within our museum, we have now poised our staff to engage in fun, inspirational ways with our guests around the content to give them an opportunity for contextual learning, to have fun, to provide the inspiration for which we are known, but to provide them with minds-on, hands-on experiences. These opportunities are now available for our 1.5 million visitors a year almost and to the nearly 300,000 students that visit us on field trips.

Our vision tells us to do more, though, with a series of community initiatives. We work with 57 community organizations throughout Chicago. We have developed the Institute for Quality Science Teaching in which we support the capacity and competency of our science teachers in our local school districts, and we have accepted a collaborative leadership role because none of this happens without partners. So in our Institute for Quality Teaching, that means we work with our universities to ensure the ability of our teachers to receive credit hours and endorsements through Science Chicago, a collaborative effort with 140 partners throughout the Chicago area. We have built awareness of the scientific resources in the region and built connections to them. With this work, we have the capacity to share with others how to really propel science education through informal settings.

Thank you.

[The prepared statement of Ms. Ingram follows:]

PREPARED STATEMENT OF ANDREA J. INGRAM

Introduction

Science and technology are critically important to human well-being, economic growth and a sustainable environment. In a technology-driven world, America's social and economic future depends on new generations of scientists who can help sustain our legacy of innovation and science leadership. However, increasing evidence indicates that education and engagement in science is on the decline. The statistics are dismal at national, State and local levels. By eighth grade, American students have fallen behind the leading ten nations in science. By age 15, these youth are behind 27 other nations in math skills. In Chicago, nearly two-thirds of fourth graders failed to display even the most basic level of science knowledge and skills on the National Assessment of Educational Progress (NAEP) in 2005.

Americans recognize the importance of this issue. "The State of Science in America"¹ national survey conducted by Harris Interactive® on behalf of the Museum of Science and Industry found:

- 70 percent believe America has lost its edge in science, and only 35 percent think the U.S. will be the world leader in science in the next 20 years.
- 87 percent agree that science is important and that they personally benefit from it every day.

¹Museum of Science and Industry. (2008). *The State of Science in America*. Conducted by Harris Interactive. www.stateofscience.org

- 79 percent believe science is not receiving the level of attention it deserves in our nation's schools.
- 87 percent agree that, as a nation, we must begin to devote more funding toward science education.

At a time when schools face shrinking resources and growing demands, reversing this trend depends on leadership from civic institutions that partner with families, communities and schools.

Informal learning institutions such as the Museum of Science and Industry are ideally positioned for this leadership role. Our strategic vision, robust education programming, and inspirational exhibits linked to classroom curriculum make our Museum and others like us natural partners in improving science education. Museums are visited by millions of schoolchildren every year; at the Museum of Science and Industry, over 260,000 students came on field trips in 2008, and tens of thousands more visit with their parents.

Several years ago, the Museum of Science and Industry convened a group of civic leaders, scientists, educators and national experts from many disciplines to brainstorm new ways to teach and inspire children, spark innovation and explore new scientific frontiers. We developed a bold plan to help us realize our vision, which is to inspire and motivate our children to reach their full potential in the fields of science, technology, medicine and engineering. This plan includes three strategies:

- Place educational programming at the heart of the Museum of Science and Industry experience by developing and expanding the Museum's Center for the Advancement of Science Education.
- Provide spectacular, transformative exhibitions that grab attention and lead to learning.
- Enhance the experience of Museum guests by presenting a unique, dynamic visit that engages people in interactive science experiences that make learning fun.

As a result, the Museum is revolutionizing the way we reach out to students, teachers, the community and school systems. Our Center for the Advancement of Science Education works with our local school systems—especially the Chicago Public Schools—and collaborates with some of the best minds and institutions focused on science and education, making the Museum of Science and Industry a laboratory for the development of science learning and teacher professional development programs.

The Center's programming aims to shape the attitudes about and participation in science by minority youth during their middle- and high-school years. The short-term goal is to increase awareness, interest, and participation in science, and longer-term goals include influencing youth to choose STEM careers, sustaining a supportive climate at the community level for science engagement and participation, and facilitating high-quality science teaching and learning in schools. The Museum's approach is multifaceted and targets students, teachers, community organizations, and families at a community-wide level. We are also a proving ground, thoroughly analyzing and evaluating our programs and implementing the best ideas.

Research indicates it's critical to align educational programs for students and professional development opportunities for teachers to classroom curriculum to ensure that programs directly impact learning.² An inquiry-based science curriculum helps bridge school science and real-world experiences.³ Studies show that when this approach is incorporated in science teaching, students (and particularly historically under-served minority students) score higher on science achievement tests, have improved science process skills, and have more positive attitudes toward science than students taught using only a traditional approach.^{4,5} The Museum of Science and Industry makes sure the content of our workshops for students and teachers meets state and national learning standards in science. Using Illinois Learning Standards in science and the *Atlas of Science Literacy* created by the American Association for the Advancement of Science's Project 2061, we match program content to what stu-

²"Teaching Teachers: Professional Development to Improve Student Achievement," *Research Points*, American Education Research Association, Summer 2005, Vol. 3 Issue 1.

³National Research Council. (1996). *National Science Education Standards*. National Committee on Science Education Standards and Assessment. Washington, D.C.: National Academy Press.

⁴Basu, S., and Calabrese-Barton, A. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching*, 44(3), 466–489.

⁵Gibson, H., and Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes towards science. *Science Education*, 86(5), 693–705.

dents need to learn as they move from kindergarten through 12th grade. Our efforts have been recognized by AAAS Project 2061, which enlisted our help to develop and host an upcoming workshop for science museum staff called “Using *Atlas of Science Literacy* in Informal Science Learning Settings.”

Educational Programming Inspires and Informs

The Museum of Science and Industry has placed education at the center of what we do. We are no longer a museum with an “education department”; we are an educational institution. As cross-disciplinary teams, we develop and implement a variety of strategies to engage and inspire our audiences through our exhibitions and programming.

We currently have three new permanent exhibitions under design and development. We have taken a materially different approach by integrating education experts onto the design teams to ensure the content is developmentally appropriate for our youth audiences, includes content that corresponds to classroom learning standards, and reflects evidence-based practices on learning. For example, *Science Storms*, a new exhibition under construction, will use seven iconic natural phenomena—avalanches, tornadoes, sunlight, tsunamis, atoms in motion, lightning and fire—to teach principles of physics and chemistry. One-of-a-kind science experiences—such as measuring wind speed, humidity and temperature while standing inside a 40-foot tornado or creating lightning indoors with a 23-foot Tesla coil—will make the exhibition a living laboratory for students on field trips. The experiences and exhibitions being created will not only make the Museum a premier global destination, but will become imperative learning tools for advancing science education.

The Museum recognizes that teachers, mentors, parents, other caregivers, and peers all play critical roles in supporting a young person’s access to and enthusiasm for science learning. By taking a comprehensive approach to science education, we aim to connect the Museum and the community in a sustainable partnership where learning takes place in many different locations. To this end, programs offered by the Museum’s Center for the Advancement of Science Education are designed to extend the content of our exhibitions through strategies that empower teachers, engage the community, and excite students. Initiatives reach beyond the Museum walls into schools and community organizations across the Chicago area. Programs are designed to provide much-needed support to teachers, reach children in a variety of settings, and make it easy to participate.

Teacher Professional Development Programs

Effective classroom teaching is critical to helping children develop the essential thinking skills they need to weigh evidence, solve problems, balance risks and rewards, and make sense of their environment. In the Museum’s new Institute for Quality Science Teaching (IQST), middle-school science teachers dive into professional development workshops where they explore science topics relevant to their classroom science curriculum and return to the classroom with new ideas, greater confidence and the resources they need to make science engaging for their students. Our focus is on enabling teachers who are in the classroom today and creating a pipeline of quality teachers with the skills to inspire passion and excitement of about science. More than 1,000 teachers attend IQST programs each year, ultimately impacting science education for an estimated 30,000 students annually.⁶

Our goal is to provide quality professional development while working with the Chicago Public Schools (CPS) towards placing a content-qualified teacher in every middle grades science classroom. CPS recently adopted a policy that will require that all middle-school teachers who teach science must have a science endorsement. We work in partnership with CPS to reach that goal and do it in a way that ensures the endorsement is of a quality that will have an impact on classroom achievement. For three years the IQST at the Museum’s Center for the Advancement of Science Education has tested and learned from partnerships with institutions of higher learning to determine what model works most effectively for the teachers and the achievement of their students.

- a) **National Louis University:** The College of Education at National Louis University offers course credit ranging from one to three credit hours for IQST programs. Participants in summer institutes offered in partnership with Golden Apple Foundation can earn one hour while teachers in one of

⁶In the 2007–2008 academic year a total of over 300 teachers participated in IQST programs certified for one to three credit hours with an additional 450 participating in more targeted half-day to full-day workshops. Over 250 additional teachers participate in events designed to inform and deepen the relationship amongst science teachers.

our year-long workshop series can earn three hours. Credits are widely transferable. Teachers must register with National Louis and pay tuition. Even when this was the only option offered in the 2007–2008 academic year, few teachers participated as the tuition is viewed as prohibitive.

- b) **Illinois Institute of Technology (IIT):** Through this collaboration, three hours of graduate course credit is offered at a reduced tuition rate of \$100 per credit hour. Nearly one-third of the teachers in our core teacher professional development series in 2008–2009 elected to enroll with IIT. Teacher participants selecting this option are responsible for paying all tuition costs. IQST and IIT are working towards a joint endorsement program. The program will enable teachers to enroll in a combination of IQST programs and IIT courses that would lead to a science endorsement with an option to add a middle grades endorsement. The planning for this project will continue through 2009, with the potential to launch the new endorsement program during 2010. Upon evaluating the success of the endorsement program, an option for a joint Master's may be considered.
- c) **Loyola University:** The Museum is a partner with the Center for Math and Science Education at Loyola University Chicago in a planning grant received from the Illinois Board of Higher Education. Through this partnership, IQST will offer its professional development programs and other approved courses as part of new degree programs leading to a Master's in either Chemistry Education or Earth and Space Science Education. Loyola will be the first in the area to offer content-specific science education degrees including content and grade level endorsements. The Museum's component of the course work is anticipated to begin in 2010.
- d) **Other partnerships:** In addition, IQST is approved to grant Continuing Professional Development Units (CPDUs) through the Illinois State Board of Education and approved to offer CPS Lane Placement Credits to teachers participating in its programs.

Credentials themselves are not enough. With our partners we work to ensure that our instruction will have an impact on student science achievement.

The Museum's professional development workshops are designed to increase teachers' knowledge of science content, improve their teaching skills and demonstrate how to use museum programs and exhibits to enhance science curriculum. We offer a year-long workshop series targeting 4th through 8th grade educators with limited experience teaching science. Currently we run two concurrent series:

- *Get Energized!* explores concepts related to energy, such as energy transformation and conversion, electricity, sound, light, heat and more. Activities include a ball drop from a three-story balcony to demonstrate potential and kinetic energy, dissecting flashlights, creating circuit boards from everyday materials and more.
- *City Science* focuses on topics such as city ecology, the science behind structures, developing cities of the future and more. Activities include exploring the school yard ecosystem, studying types of pollution, constructing buildings and more.

The menu of topics is being expanded and soon will include five distinct courses.

Success depends not just on the right content but evidence-based delivery practices. We focus on building whole school engagement and teacher communities. Principals must be on board and benefits are conferred that can extend beyond the individual teachers who are enrolled. Teachers are recruited in pairs to ensure shared resources and continuity within schools, and most are from Chicago Public Schools. The program targets schools most in need of resources—42 of the 50 schools participating in the 2008–2009 school year largely serve low-income children.

Teachers attend five day-long sessions a year, where Museum educators present topic-focused, inquiry-based, hands-on science activities. To improve accessibility, the Museum has identified and removed barriers to participation. Workshops are offered at no cost, content is aligned with Illinois Learning Standards in science, teachers receive continuing education credit, and the Museum funds the cost of a substitute teacher for sessions held on school days. Teachers receive lesson plans, all the materials they need to replicate the activities in their classrooms, and a class field trip that includes funding for buses and an educational program for school groups. The Museum's collaboration with IIT also offers teachers in the workshop series three hours of graduate course credit at a reduced tuition rate.

Teachers credit the workshops with showing them how to make science fun and exciting for their students. They say the comprehensive lesson plans, materials and

interactive training sessions provide exactly what they need to help their students learn science. Here's just some of the feedback we've received:

"I came into teaching not wanting to touch science with a 10-foot pole, and not having the know-how to do so anyway. I really credit your professional development programs with completely changing that. The training, the materials, the lesson plans, everything has been exactly what a teacher needs. I for one have learned to love science (and know a lot more about teaching inquiry and assessment) and have decided to make science education my full focus. So again, thank you for helping inspire and prepare me for this challenge. The museum is a great resource to the kids in Chicago and I have not seen any other institution do so much to make its offerings so available and accessible to the community."

—Eric Santos, Fulton Elementary School, Chicago

"This is my first year teaching and I'm doing so in areas that are outside of my original certification. Although I now see myself as a science teacher, I still lack many tools of the trade, since I never took a science methods class or student taught under a science mentor. Because I'm teaching 8th grade physical science this year, the Get Energized workshops have been exceedingly valuable in making up for those deficiencies. The lessons are really approachable and easy to implement, and the focus on inquiry fits my teaching philosophy The supplemental resources have been great as well. I cannot get over the lab materials we receive after each session. It's amazing to be able to bring those bins back to school and know that I can dig into my new lessons starting Monday. It demonstrates how complete the program is, given that you give us curricula, guide us during the workshops in how we may teach many of the lessons, and give us everything we need to put them to use in the classroom."

—Melissa Resh, Young Women's Leadership Charter School, Chicago

Community Initiatives

The Museum of Science and Industry is creating programs that expand our role in a community. New partnerships with schools and community organizations are extending science engagement beyond the classroom and Museum walls into places where students already spend their time after school. As a result, children and teens from diverse backgrounds get an opportunity to discover new interests, develop new skills, prepare for college, and learn about careers in science and engineering. The focus of the Science Minors series of programs is on children and teens in the community who are in need of new opportunities. The series includes three levels of engagement which reach over 5,000 students each year.

The Museum partners with schools and community-based organizations to offer pre-teen students early, hands-on exposure to science through after-school Science Minors Clubs. The program aims to increase science literacy and interest in science in under-served neighborhoods. Currently, there are 57 sites throughout the Chicago region and Northwest Indiana that serve about 4,700 students. Participating organizations receive science curriculum modules, training and on-site support, materials for hands-on activities, and a field trip and Family Day at the Museum. The clubs emphasize informal learning that builds curiosity and encourages teamwork. Out-of-school time science programs are associated with more positive attitudes toward science and increased interest in science careers.⁷

In the second level, teens in the Science Minors youth development program attend 10 weeks of science education and training by Museum staff and outside scientists and volunteer to demonstrate science experiments for Museum guests. Throughout their work, Science Minors gain a better understanding of science, a first-hand look at science career opportunities, and public speaking skills. Since the program's debut in 2003, about 400 teens have participated.

In the third and most engaging level, Science Achievers deepen their work with the Museum by pursuing more rigorous science topics and preparing for college and careers. These teens participate in internships, mentor new classes of Science Minors and even facilitate Science Minors Clubs themselves. They have access to more advanced science experiences and receive additional college and career readiness. This program is based on research that indicates programs that incorporate role

⁷National 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.

models, internships, and college-preparation activities have been shown to increase self-confidence and interest in STEM courses and careers, as well as improving science knowledge and skills and graduation rates.^{8,9,10}

The Museum's community programs are designed as a pipeline that feed each other. Students in science clubs can join Science Minors as teens and go on to become Science Achievers, where they have the chance to go back and facilitate a science club, creating a cycle that connects to the community. Students credit these programs with showing them the range of science careers that exist, teaching them to be effective public speakers and demonstrating the benefits of teamwork. After-school program providers credit the program with exposing younger children to new ideas and opportunities. Here's some of the feedback we've received:

"Science is a challenge for our students, but the moment they get into it, because it's so fun and hands-on and interactive, they look forward to it. After school, they expect to have fun, but this program lets them learn, too. When they love what they do here, that feeling transfers over to what they're doing in school."

—Jose Sanchez, Senior Program Director, Miracle Center, Chicago

School Group Programs

Children are drawn to engaging, hands-on learning opportunities that allow them to explore new ideas at their own pace. School groups visiting the Museum of Science and Industry participate in inquiry-based Learning Labs, which use the Museum's captivating spaces to investigate the science behind everyday life.

Learning Labs provide facilitated, focused, engaging learning experiences for school groups. Over 16,000 students each year in grades 3 through 12 participate in hands-on sessions led by Museum educators that are aligned with Illinois Learning Standards in science. Learning Labs have pre- and post-visit activities along with additional resources to enhance what students learn once they return to their classroom. Topics include renewable energy (where students build hydrogen fuel cell cars to discover how some of the latest renewable energy resources work) and advanced forensics (where students use techniques such as DNA analysis, forensic anthropology and trace evidence analysis to solve a crime).

The Museum's popular videoconference program connects an on-site classroom of students with three other remote locations anywhere in the world. This technology is a unique way to provide students on field trips with access to real science professionals. *Live . . . from the Heart*, the Museum's premiere videoconferencing program, offers students in grades 8 through 12 a dramatic exploration of the human heart. Students watch live open-heart surgery being done at a Chicago-area hospital and talk to the surgical team, ask questions about the procedure, get tips on keeping their heart healthy and find out about exciting careers in medicine. Since the program debuted in 2003, more than 17,000 students have participated. Demand for the program is high; all sessions are booked before the school year begins, and more than 40 schools are on the waiting list.

Civic Leadership in Advancing Science Education

Building on its robust set of programs, the Museum of Science and Industry is leading a collaborative effort to broadly impact science education. Science Chicago is a collaboration of more than 140 public and private institutions that have come together to present the world's largest science celebration. Designed to awaken the inner scientist in each and every one of us, thousands of dynamic and interactive activities provide hands-on learning; spur thoughtful debate; enhance classroom learning; and build enthusiasm for the pursuit of cutting-edge science while establishing the critical value of science and math education.

Our vision is to awaken Chicagoans to the wonders of our region's scientific resources and the importance of science to our future. We have worked to create a strategic framework connecting people, organizations, and opportunities to Chicago's wealth of science and technology resources. Our goal is to accomplish this vision by

⁸Darke, K., Clewell, B., & Sevo, R. (2002). Meeting the challenge: The impact of the National Science Foundation's Program for Women and Girls. *Journal of Women and Minorities in Science and Engineering*, 8(3/4), 285–303.

⁹Degenhart, S.H., Wingenbach, G.J., Dooley, K.E., Lindner, J.R., Mowen, D.L., & Johnson, L. (2007). Middle school students' attitudes toward pursuing careers in science, technology, engineering and math. *NACTA Journal*, 51(1), 52–60.

¹⁰Building Engineering and Science Talent. (2004). *What it takes: Pre-K–12 design principles to broaden participation in science, technology, engineering, and mathematics*. Available at www.bestworkforce.org/publications.htm

creating an organizational and programmatic framework to achieve five overarching goals:

- Engage young people in the fun, excitement and awe of science and inspire them to consider careers in science and technology fields.
- Raise awareness of the importance of science in everyday life in the minds of students, their parents and teachers—and thereby, the public at large.
- Enlighten Chicagoans to the region's vast science and technology assets.
- Encourage partnership and collaboration between and among the science and technology community and our target audience.
- Raise Chicago's profile as a national leader in science and technology, and promote the message that our city and region can and will continue to prosper because we are committed to supporting science and technology.

With the network built by the Museum of Science and Industry and the over 140 partner institutions that are part of Science Chicago, we have propelled the richness of our region's scientific resources to the forefront of public awareness and tapped the advantages of connecting students and teachers to resources in the real and virtual world through the web. We share an understanding of the critical importance of content-prepared teachers in science classrooms and strategies to improve the prevalence of such teachers in the Chicago Public Schools.

Our opportunity now is to leverage the strength of the Science Chicago partnerships and resources to enhance the quality of science instruction in the Chicago Public Schools while continuing to serve as an important bridge between students, families and communities and the rich scientific resources of the region. Fundamentally, our goal is to provide broad opportunity to exceptional science achievement by ensuring that CPS science curriculum is aligned with national and international science achievement benchmarks and assessment, supporting CPS curriculum with quality and well-aligned professional development programs, and aligning and building access pathways to external resources.

Assessing Museums' Impact and Role

The Museum of Science and Industry is committed to evaluating the success of our educational programs. We have partnered with the Chapin Hall Center for Children at the University of Chicago to assess the real impact our programs are having on student achievement, and Chapin Hall has submitted a grant to the National Science Foundation to help fund this effort.

Educational programs provide a platform for museums to provide credible leadership in addressing the larger issues facing the advancement of science education. With other museums, educators, universities and civic leaders, the Museum of Science and Industry is committed to addressing this challenge in a meaningful, sustained manner. This means that we have committed people and resources to the policy evaluation and collaboration that will be required to move this issue of advancing science education from talk to action.

BIOGRAPHY FOR ANDREA J. INGRAM

Andrea Ingram, appointed in 2006, serves as Vice President for Education and Guest Services at the Museum of Science and Industry. Ms. Ingram is responsible for providing strategic vision and organizational management of division's four departments: Center for the Advancement of Science Education, Science Chicago, Guest Experiences and Guest Operations. All staff, contractors and volunteers responsible for engaging with guests report to this division. In addition to all revenue and retail based operations, the division's work includes developing and delivering experiences grounded in museum content through professional development of middle school science teachers; community based initiatives serving 4000 youth throughout Chicago; Learning Lab experiences targeting nearly 300,000 annual student guests, and facilitated exhibit and venue based experiences for Museum's nearly 1.5 million annual guests. The division's programming also provides a platform for the Museum's leadership role in advancing science education through public awareness and engagement initiatives such as Science Chicago as well as partnerships with local school districts to improve student access and opportunity to science achievement and careers.

Prior to joining the Museum, Ms. Ingram received an appointment to the executive management team of the Illinois Department of Children and Family Services where she played a critical role in major strategic decisions and was instrumental in the development and implementation of system wide initiatives. Prior to her ap-

pointment at the State, Ingram worked at Voices for Illinois Children as the Director of the Budget & Tax Policy Initiative. Ingram joined Voices after a decade of practicing law in a business law firm in San Francisco in which she became a partner. She has litigated cases in state and federal court involving contracts, real estate transactions, intellectual property, financial fraud, employment law, and bankruptcy and has significant trial experience.

Ingram holds a J.D. from the University of California, Davis and a B.A. in Justice from The American University in Washington, D.C. She is licensed to practice law in both Illinois and California.

Chair LIPINSKI. Thank you. Ready for Mr. Lippincott.

STATEMENT OF MR. ROBERT M. LIPPINCOTT, SENIOR VICE PRESIDENT FOR EDUCATION, THE PUBLIC BROADCASTING SERVICE (PBS)

Mr. LIPPINCOTT. Good morning, Chairman Lipinski, Ranking Member Ehlers, and esteemed Members of the Subcommittee. My name is Rob Lippincott, and I am Senior Vice President for Education at PBS. As a former teacher, I greatly appreciate the opportunity to address the most effective role of informal environments in STEM education.

Public Broadcasting was founded to lead in informal education on the air, online, on the ground, guided by research, and actively supporting educators. On the air, Public Broadcasting has been a leader in educational television for more than 50 years. Available free of charge to 99 percent of Americans' television households, PBS reaches more than 65 million people, 14 million of them kids, each week, inviting them to experience the worlds of science, history, and public affairs.

Informal science education begins with our award-winning science television programs, some of which you may recognize: NOVA, Nature, Design Squad, Curious George, and most recently, Sid the Science Kid. We even have Neil deGrasse Tyson, named the sexiest astrophysicist alive by *People* magazine, hosting our NOVA *scienceNow* magazine.

However, TV is only a small part of the informal education story. Broadband access is dramatically changing the opportunities for the Nation's educators to improve STEM education. I want to share two examples of how PBS is trying to use the web to support informal education, PBS Kids GO!, what we call a broadband channel, and a project we call EDCAR, the Educational Digital Content Asset Repository.

PBS Kids GO! is an online media portal which includes full-length TV episodes, clips and games. I believe that this is the first glimpse of what television may look like for all ages very soon.

[Video]

As you can see, kids are not just watching TV but playing with the characters, learning through games, and exploring ideas. This set of tools is a powerful first step in building STEM-savvy citizens. We need to give students at every age and their teachers increased resources to this kind of multi-modal learning.

EDCAR is a database of video and digital resources created by public media producers and our partners in museum, university, and research communities. By collecting and organizing the resources and then aligning them to learning standards, we create

the best STEM learning tools for use at home, at school, and in every learning setting.

The first offering that we are creating is based on STEM for the middle school. A teacher might use this kind of a lesson structured with an introduction and objectives to select a learning chunk of video, a small clip that has been cut to introduce—in this case a lesson on the hydrosphere, a video called “Where is the water?” or the teacher might select a very different kind of video asset or digital asset, this one based on two different images, one of the Muir glacier in August of 1941, the other in August of 2004, which in fact might lead students to want to look up this map of Arctic ice.

To truly make a difference in informal education efforts, we have developed a 360-degree approach to children, literally trying to surround them at home, school, and at play with learning opportunities in media. We are working to duplicate this success across STEM disciplines. Recent findings from rigorous studies on SuperWhy! and Between the Lions show clear and measurable gains in every area targeted. This shows that PBS is able to use media to move the needle and improve abilities of kids to learn. Again, we will be working to duplicate this success that we have had with literacy across STEM disciplines. Of course, if we really want to change learning, both informal and formal in a lasting way, we need to prepare our teachers and caregivers so they are equipped and excited about sharing science. Through PBS TeacherLine, an online professional development program, we are building a how-to course for caregivers and early preschool and after-school teachers.

[Video]

The reception of this course has been exceptional. For example, North Dakota has approved this course for its childcare providers, and this is working also in Arizona, Illinois, Louisiana, Minnesota, Tennessee and Texas. This kind of anywhere, anytime, pajama-compatible professional development is critical, and the consistent theme across all of what we are doing is partnership, and I would be happy to explain more.

Thank you very much.

[The prepared statement of Mr. Lippincott follows:]

PREPARED STATEMENT OF ROBERT M. LIPPINCOTT

Good morning, Chairman Lipinski, Ranking Member Ehlers and esteemed Members of the Subcommittee. My name is Rob Lippincott, and I am Senior Vice President—Education for PBS—the Public Broadcasting Service. As a former teacher, I greatly appreciate the opportunity to answer some of what I consider to be one of the most important questions in education today—what is the most effective role of informal environments in STEM Education?

There has never been a more critical time for both formal and informal science education and the continuing need to improve the quality of math and science education we provide our young people. Public broadcasting was founded to lead in the development of educational media, particularly informal education.

I will use my time today to give you a few digital glimpses of some of the important work PBS and the public media community is doing with respect to:

- The role of digital and electronic media in educating students
 - “on the air” with our traditional television programming;
 - “online” with some very exciting new media programming.
- The role informal education plays in broadening participation and promoting diversity in STEM fields

- “on the ground” with a “360 degree” approach to community engagement;
- Impact of research to build, deliver and assess programs;
- The importance of teacher professional development to raise teacher effectiveness.
- The role of partnerships with formal and informal education institutions.

The Role Digital and Electronic Media in STEM Education—On the Air

PBS’ best known role in informal education is an open, universally available broadcast invitation, designed to do exactly what the newest of the 6 Strands of Science Learning recommends in the recent National Academies of Science study—*Learning Science in Informal Environments: People, Places, and Pursuits*: to “experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.”

We like to say that “we educate with everything that we do” and as a system-wide survey shows, more than 97 percent of the 174 Public Broadcasting Service licensees use technology to deliver education services. For instance, Alabama Public television offers every teacher in the state access to an array of media resources and professional development in a web service called “APTPlus.”

There are many more examples as public broadcasting has been a leader in educational television for more than 50 years. With its 356 member stations and our partnerships with community organizations and institutions of higher education in virtually every state in the Nation, PBS offers all Americans the opportunity to explore new ideas and new worlds through television and online content. Available free of charge to 99 percent of America’s television households, PBS reaches more than 65 million people each week—14 million of them children—and invites them to experience the worlds of science, history, nature and public affairs.

Among the many award winning science television programs you may recognize—NOVA, Nature, Design Squad, Curious George, and, most recently, Sid the Science Kid—are leaders and models. We even have Neil deGrasse Tyson, named the “sexiest astrophysicist alive” by *People* magazine, hosting NOVA scienceNow.

The Role of Digital and Electronic Media in STEM Education—Online

Television and on-air programs, however, are a small part of the entire informal education story. Online broadband access and digital media is dramatically changing the opportunities and challenges the Nation’s educators have to improve STEM education.

PBS has two new online initiatives which I find compelling: the PBS Kids GO! Broadband “channel” and a project we call EDCAR, the Educational Digital Content Asset Repository.

The online sites which collectively comprise www.pbskids.org draw a growing audience—now over nine million two- to eight-year-olds every month. The latest experiment with the six- to eight-year-olds in this audience is called PBS Kids GO!, which presents an online media portal including full length TV episodes, clips and games. I believe that this is the first glimpse of what “television” will look like for all ages soon. Let me show you a short sample: (*PBS Kids GO! Clip*).

As you can see, kids are not just watching TV, but playing with the characters, learning through games and exploring ideas—this set of tools is a powerful first step in building STEM savvy citizens!

I believe that we need to give students at every age and their teachers increased access to this kind of learning resource. EDCAR is the project to build a comprehensive public media database of the video and related digital resources that public media producers and our partners in the museum, university, media and research communities are creating across the Nation. By collecting, organizing and aligning these resources to learning standards, we can create the best STEM learning tools for use in school, at home and in every learning setting. This project is underway with several dozen PBS stations and their partners. Let me give a very brief example of some work we are testing with teachers: (*EDCAR clip*).

Research has shown the promise of systems like this and PBS is pursuing a first offering focused on STEM skills for middle school learners. PBS and stations need a core of national standards—in the words of the Council of Chief State School Officers—“fewer, higher, clearer” academic standards to focus upon. And we need the help of the educational research community to reveal the most critical goals and best practices for us to target.

EDCAR will provide a unified reservoir of online content and services, accessible and relevant to all of America’s. These materials are produced by producers, member stations and partners across the public media community. The individual media

assets and the array of related media which comprises their educational context, offers every teacher and student a comprehensive curricular supplement in every subject from pre-school, to elementary school and through secondary school. The service is presented locally. It is designed to assist educators achieve measurable improvements in student achievement and be consistent and supportive of the standards set by State and local educators.

With each member station working with the corresponding State education agency, all of the content will be directed to the most critical targets of each community's instructional core—with particular focus on those students at risk in our urban and rural areas. The State education agencies will provide the standards which the media addresses and will lead the implementation of the media services in its schools and classrooms. The learning goals identified by the State education agencies will specify the digital media produced by public media providers to fill out the repository, allowing teachers in every part of the country to find and effectively use the content that meets their students' learning needs.

Role of Informal Education in Broadening Participation and Promoting Diversity—On the Ground

But in order to truly make a difference in informal educational efforts, we also need to go well beyond the “push” technologies of television and online program delivery. Our best example is PBS Kids Raising Readers which targets early childhood literacy where our best evidence of learning gains come from what we have called a “360 degree” approach to children—literally surrounding them at home, school and at play with learning opportunities and media. We hope to duplicate this success across STEM disciplines.

PBS KIDS Raising Readers literacy initiative, generously supported by the U.S. Department of Education in a partnership with the Corporation for Public Broadcasting targeted specifically at under-served populations and minority groups. Appendix A reveals a full discussion of how PBS stations partner with schools, colleges and community organizations nationwide (*Public Television Stations: A Trusted Source for Educating America*, Jan. 2008).

The long-term goal is to achieve measurable results in improving literacy skills of children in low-income families. We are working in 20 low socioeconomic strata markets in order to build successful models that can be replicated across the country. PBS is also eager to spread this success to STEM—to use these proven best practices in programming and engagement to broaden participation and promote diversity in every STEM discipline and field of activity.

The Role of Research

Educational media providers have learned to base all of their programming on learning research, rigorously testing every part of broadcast and online offerings. They must also now work with states to align media with recognized curricula and State standards to ensure that these materials are suited for use in formal as well as informal settings.

PBS measures the impact of its children's series to ensure that they are accomplishing their goals. Very recent findings from key studies on two children's series designed to teach early literacy skills—*SuperWhy!* and *Between the Lions*—show clear, measurable gains in every area targeted. The test results show that PBS is able to move the needle and improve the abilities of kids to learn. Again, we will be working to duplicate this success with literacy in targeted STEM disciplines.

The Role of Teacher Professional Development

But if we want to change learning—both formal and informal—in a lasting way, we need to prepare our teachers and care givers so that they are equipped and excited about sharing science. We need to invite them to become guides and coaches for learners and teachers of every STEM field.

We have some history in teacher professional development, but our most recent work is what I find the most promising. Most recently, we are building “how to” courses for pre-school and after-school teachers—caregivers, parents and early educators—to help them make every environment a learning environment. Let me show you just a moment of what teachers see: (*PBS TeacherLine “setting up your room” clip*).

PBS TeacherLine, an online professional development program funded through a U.S. Department of Education Ready to Teach grant, has the goal of making professional development accessible, affordable and engaging for teachers and care givers. I believe that this kind of “anytime/anywhere” professional development—we have

called it “pajama-compatible” can help inspire and guide formal and informal STEM learning at every age and in every discipline.

We offer more than 135 courses—35 in Science disciplines and 35 in Math. We work with 23 colleges and universities in all 50 states, through 66 PBS stations. (See Appendix B for a selected list of PBS TeacherLine partner universities and community organizations). More than 42,000 educators have taken a course since 2004. Graduate credit-bearing courses help teachers remain certified. A growing set of tools support teacher leaders in their professional learning communities. Recently published research (in the *Journal of Computing in Teacher Education*, Fall 2008) attests to the effectiveness of this medium to build teachers’ “competence and confidence in instructional technology integration.”

The Role of Partnerships

A consistent theme I hope you have heard is “partnership.” PBS and its member stations are only part of any collective effort to build a scientifically literate community. The federal partnership is crucial in this process. PBS has received generous support from the Department of Education for our *Ready to Learn* and *Ready to Teach* initiatives. Last year the *Ready to Compete Act* which reauthorizes both of these programs, was introduced by Congressman John Yarmuth from Kentucky. We hope it will be introduced again in this new Congress and receive the strong support we believe it deserves.

The kind of research, truly a scientific discipline and a burdensome cost to producers, is critical to establishing the techniques and practices public media producers need to serve educational goals. We continue to need academic and research partners in universities and key government agencies, including the National Science Foundation, the National Institutes for Health, NASA, and NOAA. We have good working relationships with each of these agencies and strongly support their programs.

Conclusion

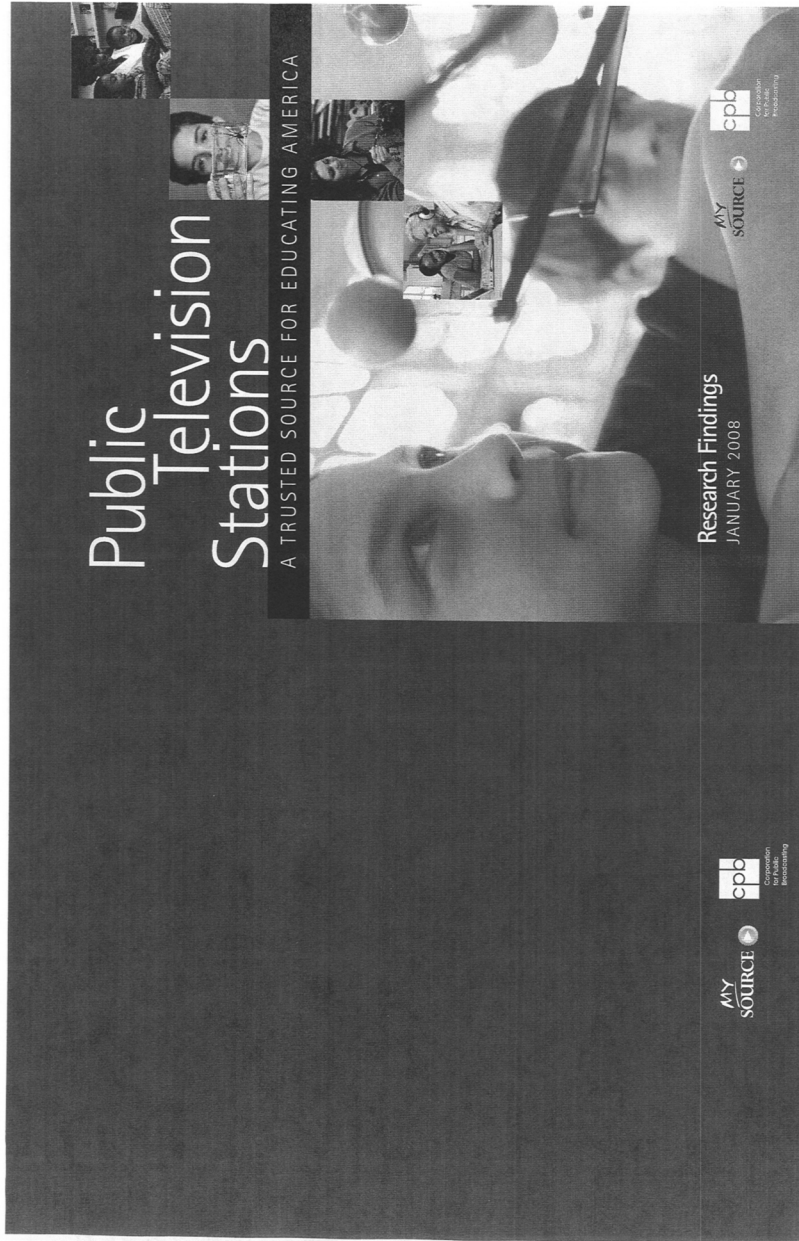
I hope I have helped to make a case today for the importance of the role informal environments play as well as the urgency of the effort to target science, technology, engineering and mathematics learning. I see this as one of the most vital roles the public media community has to play: on the air, online, on the ground, guided by research, and actively supporting educators.

There is very promising evidence that media is a powerful way to facilitate learning in and out of the classroom. We need to apply the lessons we have learning producing appealing television programs, effective educational media resources and “360 degree” community engagement for topics like literacy to the urgent problems of STEM education.

I want to close by once again expressing my appreciation to the Subcommittee for the opportunity to appear today to discuss the role of informal science education. The Academies’ new report suggests that there is strong evidence that we are on the right track. But I think we would all agree that we still have a long way to go to ensure all of our students have the scientific and technical literacy and know-how needed to compete in today’s highly competitive marketplace. PBS and its members are committed to playing an appropriate role using our resources and access via the audiences we serve.

Thank you.

Appendix A



Education continues to be a core value of the public broadcasting community as it has been since its inception. In fact, the Corporation for

Public Broadcasting's mission underscores the critical role of our work to "provide programs and services which inform, enlighten and enrich the public."

Foreword

Education continues to be a core value of the public broadcasting community as it has been since its inception. In fact, the Corporation for Public Broadcasting's mission underscores the critical role of our work to "provide programs and services which inform, enlighten and enrich the public."

This year, as we mark the 40th anniversary of the Public Broadcasting Act, I am especially pleased to provide this new research report, affirming the robust and vital contribution public television stations make when it comes to education and an informed and strengthened civil society.

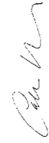
As a nation, we are confronting serious challenges as we seek to educate this and future generations: low literacy rates, lack of student achievement in math and science, and college and work readiness. Public television is committed to helping meet these challenges through high quality on-air programming and, beyond the broadcast, through our educational services.

This report spotlights how public television's educational services, tailored to meet the unique needs of diverse communities, are giving our nation's children and youth the opportunity to learn. More than 95 percent of public television stations are engaged in providing educational services with 76 percent partnering with K-12 schools and 68 percent working hand in hand with colleges and universities.

Educational services provided by public television stations range from special in-person reading programs for parents and childcare providers, to professional development resources for teachers, to online activities designed to spark student learning in subjects such as science and math, and much more. In today's multi-media world, more than 97 percent of public television stations use technology to deliver their services.

Through the Corporation for Public Broadcasting's public awareness initiative and its *My Source* national theme, we are inviting audiences to share in their own words how public broadcasting matters in their lives and communities. Through the exciting *My Source* initiative, teachers, parents and students are sharing stories about the impact of public television's education programs and services in their daily lives.

These stories will affirm in powerful ways the research findings detailed in this report. These are findings which reinforce public broadcasting's role as a trusted and essential source in creating informed and educated citizens.



President and Chief Executive Officer
Corporation for Public Broadcasting

This report tells an exciting story about public television's educational services and the myriad ways in which they go above and beyond...

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Introduction

Inform, Enlighten, Enrich. These are three cornerstones upon which public broadcasting relies as it carries out the important charge of educating America. When President Lyndon B. Johnson signed into law The Public Broadcasting Act of 1967, he challenged the Corporation for Public Broadcasting to prove that "what educates can also be exciting."

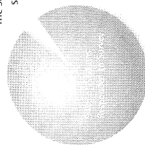
Forty years after the signing of the Public Broadcasting Act, public broadcasting remains committed to meeting this challenge—to educating Americans. Now more than ever, public broadcasting is dedicated to measuring the impact of its work. The success of public broadcasting's educational mission means success for America, beginning with young children who learn to count and read and extending well beyond to lifelong learning. Gauging progress and success are important activities in the pursuit of this goal.

In the case of broadcast television, success is determined through viewership ratings and viewer impressions. Public television, however, educates America far beyond the broadcast. This report is an important first step towards documenting the impact of public television's efforts to educate America.

2007 Education Services Survey

In July 2007, with the guidance of the Education Committee of public television's Affinity Group Coalition, the Corporation for Public Broadcasting contracted with SRI International, an independent, nonprofit research institute, to conduct a survey to document the education services currently offered by public television stations and the services that stations aspire to provide in coming years.

The survey purposely did not ask about broadcast programs aired by these stations, but rather the off-air educational services that they provide to their communities. The survey challenged stations to describe their education programs, audiences, technology, and how they evaluate the implementation and impact of their important education-related work.



I believe the time has come to enlist the computer and the satellite, as well as television and radio, and to enlist them in the cause of education."

—President Lyndon B. Johnson upon signing The Public Broadcasting Act of 1967

Education services were defined as follows:

ACTIVITIES
Projects that involve station audience(s) in structured learning activities developed or aggregated by the station for a particular education purpose.

- For example:
- A professional development institute for the community's childcare providers.
 - An online professional development course for high school science teachers.

RESOURCES
Tools that provide access to materials and content developed or aggregated by the station for use by station audiences.

- For example:
- Web portals containing digital learning resources—a thematic unit on measurement.
 - Curriculum distribution services targeted to teachers within a station's service area.

In total, 165 licensees responded to the survey representing a significant 94% response rate. Results of the 2007 survey paint an encouraging picture of diverse education services that serve equally diverse communities. Rooted in community needs and effective partnerships, the results show a prolific and dedicated network of educational programs and services.

Excerpts from the Public Broadcasting Act of 1967

The Congress hereby declares that—

- It is in the public interest to encourage the growth and development of public radio and television broadcasting, including the use of such media for instructional, educational, and cultural purposes;
- Expansion and development of public telecommunications and the diversity of its programming depend on freedom, imagination, and initiative on both local and national levels;
- It is in the public interest to encourage the development of programming that involves creative risks and that addresses the needs of unserved and underserved audiences, particularly children and minorities; and
- Public television and radio stations and public telecommunications services constitute valuable local community resources for utilizing electronic media to address national concerns and solve local problems through community programs and outreach programs.

Public Television Stations Educate America

Results of the 2007 Education Services Survey demonstrate that public television stations across the country are actively fulfilling the charge and commitment to educate America. Comprehensive reports filed by 165 public television stations reveal the following 10 findings:

1. **Education is a core value for public television stations.** The Public Broadcasting Act's commitment to educate America is realized through the shared commitments of public television stations to the communities they serve. Education is a prominent feature of station missions and strategic plans. Their visions are carried out through thousands of programs and services that address local needs and opportunities. Regardless of station size, location, or type of licensee, education's is affirmed through public television's mission and resulting actions.

Education Survey Highlights

- 92% of stations have an education presence in their communities. This is consistent across public television stations—whether large or small and regardless of being a university, state, or community-based licensee.
- 89% of stations point to an education focus in their strategic plans.
- 83% of stations include education in their mission statements.
- 84% of stations directly offer education services to their communities—services that go far beyond broadcast programming.



2. **Public television stations provide education services tailored to the diverse needs of the communities they serve.** As partners with local communities, public broadcasters align their education services with the unique needs of their communities. Public television stations offer thousands of services ranging from teacher professional development to support for English language learners. Public broadcasters work closely with community leaders and educators to develop and implement high-quality programs. As a result, people know to turn to public television as their source for learning as well as entertainment.

Education Survey Highlights

- 63% of stations consider local, regional or national needs to guide education services decisions.
- Stations identified a diverse range of programs and services that reflect the diversity of their audiences' needs. This diversity is reflected in the following sampling of audiences served by public television stations:
 - > Parents of young children—76% of stations;
 - > School-aged children—67%;
 - > Pre-school aged children—65%;
 - > Adult learners seeking a General Educational Development (GED) credential—64%;
- Stations reach community members through various delivery strategies. Whether in-person classes, programs that blend in-person and technology-based learning, or completely online resources, audiences gain the content they need through the most efficient and effective means.

WNED Buffalo's ThinkBright

WNED Buffalo carefully assessed its community to identify and prioritize the critical challenges it faced. The ThinkBright Lifelong Learning program is one response designed to specifically address these identified needs. WNED Buffalo's ThinkBright includes a digital television channel and an online service to help teachers and students to achieve higher academic standards, help parents influence the growth of children's learning at home, and address job readiness issues for at-risk adults. It supports and enhances the educational experiences of teachers, students, families, and adult learners throughout New York State.

ThinkBright includes:

- Parent gateway—support for parents seeking information about helping children achieve in school, child health and wellness, and family support groups;
- Student resources—including homework help and how to cope with difficult or stressful situations at school;
- Teacher tools—curriculum resources and professional development and
- Adult education—including GED and services for English language learners.

For more information: www.thinkbright.org

Public Television Station Partners with Local Agencies and Community Reaps Benefits

In 2006, WGBH Boston, The Boston Children's Museum, The Boston Public Library, Children's Hospital Boston, and the Boston Public Health Commission launched a major asthma management campaign aimed at black and Latino children in neighborhoods with the highest incidence of asthma. Titled "Kids with Asthma Can..." this program builds on the enormous appeal of WGBH's popular *Arthur* series, which featured an award-winning episode dealing with asthma.

The campaign draws upon the strengths and resources of all partners to ensure community impact. It involves the following activities:

- Family-oriented booklets and reading lists aligned with relevant episodes of the *Arthur* series and a play based on an episode that will be performed in libraries, museums, and community centers;
- Targeted community outreach activities, including health seminars at public libraries for parents and caregivers, and workshops for community health center staff; and
- A highly visible media campaign launched during Asthma Awareness Month (May) and to continue into the summer months when asthma episodes peak.

For more information: www.wgbh.org/asthma

3. **Partnerships with local schools, universities, museums, libraries, community organizations, and others increase the reach and impact of public television's education services.** Public television is dedicated to serving the widest audience possible and strategic partnerships offer significant reach and impact. Stations report that their partnerships provide opportunities to work with other leaders in communities to enhance teaching and learning, and to expand public television services to new audiences in need.

Education Survey Highlights

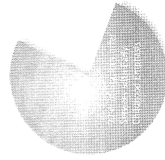
- Stations frequently partner with:
 - > K-12 schools and districts—76% of stations;
 - > Colleges or universities—68%;
 - > Community service organizations—65%; and
 - > Public libraries—44%.

- 13% of stations report having a partnership with each of the types of partners described above.

4. **Public television is a critical resource for early childhood development.** From birth through preschool, children are gaining a foundation for much of what they will learn in their formal K-12 years. These first five years of life are when children learn best and most—and public television is with children every step of the way. With more than 35 years of experience in delivering research-based content to early learners, public television has made extraordinary progress in impacting early childhood education. Education services are successfully serving America's children, their parents and the early childhood educators with whom they work.

Education Survey Highlights

- 77% of stations offer education services with an early childhood emphasis.
- 75% of stations offer education services to parents of young children.
- 69% of stations offer education services in child development.
- 62% of stations provide education services to preschool instructors or childcare providers (61%).
- This important early childhood work is most often accomplished through in-person classes and forums.
 - > 62% of stations have in-person services for childcare providers.
 - > 61% of stations have in-person services for pre-school instructors.
- When asked to name the service that provides the greatest value or benefit, 40% of stations identified Ready to Learn as the most valuable service. For any other single initiative or program, these programs are both designed to help children ages 2-8 learn to read through engaging television and other electronic content, coding games, Web Sites, and easy-to-use learning resources for kids, parents, caregivers, and teachers.



5. **Public television is a resource for K-12 educators and helps increase student learning.** Public television continues to support the educational development of children during their formal school years. In fact, the most common partnership for public television stations is one with a K-12 school or district. Developing teachers with the intent of improving classroom effectiveness is a common goal for public television stations across the nation. Public television stations work to improve student performance through relevant and engaging content. Stations also work to align education services with state and national standards to ensure continued relevancy and utility.

Education Survey Highlights

- 85% of stations offer content aligned to local, state, or national education standards.
- 67% of stations offer content for school-aged children (ages 6-18).
- 78% of stations offer education services to K-12 teachers and administrators.
- Stations offer teacher professional development programs and activities that focus on:
 - > Media literacy—46% of stations;
 - > Science—42%;
 - > Technology—42%;
 - > History—33%.
- Stations work to develop teachers and improve their effectiveness in the classroom. Nationwide, these services include the following emphases:
 - > Increasing teacher subject and content knowledge in areas such as social studies, arts, history, math and science—69% of stations;
 - > Teaching strategies—52%;
 - > Teaching with technology—47%; and
 - > Assessment strategies and tools—27%.

KAET ASSET

Since 1983, ASSET—Arizona School Services through Educational Technology—has helped Arizona K-12 educators integrate technology into their classrooms. What began as an agreement to cost-effectively distribute instructional video statewide, has grown into an organization that offers a broad array of services for educators.

ASSET is a self-supported department of Eight/KAET public television located at Arizona State University. ASSET takes great pride in collaborating with business and non-profit organizations to bring the best possible resources to Arizona educators. ASSET has a primary focus on customizing local and national PBS content for Arizona classrooms.

ASSET resources include:

- Professional development online courses;
- Digitally-streamed instructional videos aligned with Arizona Academic Standards;
- Professional readings; and
- Educationally-relevant websites.

For more information: www.asset.asu.edu

6. **Public television stations have a long history of working with universities.** Universities are often located in the center of communities. With their commitment to education, public television stations share similar missions. In its earliest years, public television pioneered distance education, much of which originated from universities. Today, it continues to support higher education through education services on issues such as science, technology, engineering and mathematics (STEM) proficiency that impact students and faculty alike.

Education Survey Highlights

- 58 stations are licensed to universities.
- 88% of stations have established partnerships with universities.
- 61% of stations offer services to college or university students (undergraduate or graduate).
- 52% of stations offer services to college or university instructors.

WHYY's CollegeAnywhere

CollegeAnywhere is a unique partnership between higher education institutions that are leaders in distance learning and WHYY, Philadelphia's leading public broadcaster. WHYY's mission since its founding nearly 50 years ago has been lifelong learning. The station first assembled a group of local colleges to support televised courses in 1980's. The consortium pioneered the concept of integrated, multi-venue distance learning products to support specific higher education needs—including the successful addition of fax, voice mail, and video playback within a standard course management system.

Today, its Adult Learning Service includes adult basic education, higher education and professional development courses. CollegeAnywhere delivers quality distance learning to faculty and students with innovative technologies designed to enhance online learning. Input from faculty and students drive the resulting feature-rich products. More than 5,000 accounts are currently streamed through WHYY.

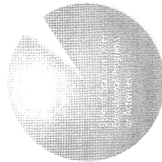
WHYY's Home College Service complements CollegeAnywhere by providing a way for students to earn college credit from home. Established in 1996 with the purpose of making more education available to more people, students come from all walks of life to fulfill their lifelong dream of earning a college degree.

For more information: www.collegeanywhere.org

7. **Public television stations provide high-value content.** Rather than offering turn-key solutions, public television stations create and tailor rigorous content to match the education needs of their audiences and communities. Educational content is built collaboratively by public broadcasters and institutions and organizations in the communities they serve. It is shaped by public television's decades of experience working with communities and expertise in program design and implementation.

Education Survey Highlights

- 95% of stations offer educational programs or activities, defined as content-rich, structured learning experiences, as part of their education services.
- 74% of stations offer education services that address science, technology, engineering and mathematics (STEM) content.
- Other content areas commonly addressed by public television stations include:
 - > Media literacy—73%;
 - > Basic literacy—70%; and
 - > Child development—69%.



Public Television Stations
A Trusted Source for Educating America

Public Television Stations  A Trusted Source for Educating America

Education Survey Highlights

- 97% of stations use some form of technology to deliver education services. DVD and Internet-based delivery are the most commonly employed technologies currently.
- Stations named broadband as the technology that holds the most promise for advancing the educational mission of public broadcasting. Many stations consider broadband essential as they move towards delivery using multiple interconnected digital platforms.
- Video on Demand (VOD), video streaming, podcasts, datacasting and gaming are technologies being implemented or considered by public television stations to enhance and distribute their education services.
- 50% of stations have purchased technology to support the education services they provide.

9. Public television's education services continue to evolve within a culture of continuous improvement. Public broadcasting is committed to providing not only educational programs and services, but effective ones. Decades of experience have helped public television stations hone and perfect the education services they provide. For example, public broadcasters know that results take time. The services they design and implement regularly stand the test of time—with the most effective programs being in place for four or more years. With a dedication to continuous improvement, station education staffs regularly monitor and adjust their education services to ensure effectiveness and impact.

Education Survey Highlights

- As experts in providing education services that respond to community needs, public television stations have learned over time that effective programs share some common attributes:
 - > Funded: services are funded by the station, an external source, or a combination of sources.
 - > Sustained: services are optimized over time, remaining in place for more than four years.
 - > Credited: some form of credit is offered in exchange for participation (recognition, continuing education credit, qualification in a particular skill set).
 - > Personalized: include a face-to-face element that engages participants and prompts continued participation.
- 93% of stations plan to make changes to education services in the coming year. This illustrates a commitment to ongoing education services improvement.



KQED QUEST

KQED's QUEST is a new multimedia series about the people behind San Francisco Bay Area science and environmental issues and how their work is changing the way we live. QUEST's geographic coverage spans from Mendocino to Monterey and from Sacramento to Santa Clara, and focuses on nine content areas: astronomy, biology, chemistry, engineering, environment, geology, health, physics and weather.

QUEST utilizes all of the station's media platforms: educational resources and extraordinary partnerships. The program includes a half-hour weekly HD television program, weekly radio segments, an innovative website and unique education guides. At the center of QUEST is a website that presents radio and television content, along with many unique features:

- Interactive map created with Global Positioning Satellite technology to "zoom" locations and images where QUEST segments were filmed and recorded;
- Partner locations where visitors can experience science, environment and nature first-hand, also are highlighted on the map;
- "Explorations"—nature hikes and walks with a strong science theme;
- New community science blog with daily contributions from scientists, experts, teachers and students with a different Bay Area perspective; and
- Discussion groups, photo sharing and special "web only" content.

Additional resources help ensure access and extend QUEST's reach. They include:

- Education guides—tailored for both outside and inside the classroom;
- Media workshops—to train educators on how to use QUEST stories in educational settings; and
- QUESTing, educational treasure hunts—that encourage participants to get out and connect with their natural surroundings in a fun and meaningful way.

For more information: www.kqed.org/quest

8. Public television stations use technology to create and broadly distribute education services. Technology shares a strong relationship with public television—a relationship initially sparked by education. Colleges and universities turned to instructional television, the forerunner of public television, to reach learners at a distance. Today, public television stations are on the cutting-edge of technology advancements, planning for and testing emergent technologies that hold promise for delivering educational content. Education and technology remain intertwined and are seen as the drivers for public television's future success.

10. **For public television, demonstrating impact is important business.** While public television stations can readily point to their successes through program participant feedback, hard evidence about individual and community impact is more difficult to find. This station survey has established a baseline by documenting current practices. But this is only a first step. Public television is committed to measuring its success and plans to do so through a variety of strategies—some currently in place, and others just beginning.

Education Survey Highlights

- Historically, stations have used surveys (65%), interviews or focus groups (33%) and conversations or informal input (65%) to solicit feedback about educational services.
- Today, public television is supplementing historical measurement approaches with a return-on-investment strategy.
 - > The Ready to Learn initiative, which involves development of new research-based educational programs and services for young children, includes 56 empirical studies designed to ensure program quality and provide proof of learning impact for the children served.
 - > CPE's Impact Evaluation initiative seeks to build the capacity of public broadcasting stations to measure, evaluate, and communicate the impact of their education services on their local communities. Evaluation tools and training will help public broadcasters conduct this important work. Key measures to be collected by each public broadcasting station and aggregated into a national summary will further quantify and monitor public media's educational impact.

Conclusion

Public television has accomplished much during its 40-year history. Today, our nation faces new challenges in educating America, and public television has been a leader in working with communities to meet these challenges.

Results of the Education Survey have documented the significant work being accomplished in communities across the nation. It demonstrates that public television continues to educate its diverse audiences by providing thoughtful, relevant and engaging content, implementing a wide variety of programs and services, and building strategic partnerships in their local communities.

In the coming years, stations will dedicate themselves to developing new educational content and implementing new technologies. Broadband advances and other digital technologies will enhance and extend the reach of current services. Stations are already at work building new content for teachers, in areas including emergent literacy, early childhood development, STEM education and workforce development. With their strong dedication to making continual improvements, 93% of stations plan to make changes to their education services in the coming year.

In a climate of increasing global competitiveness, public television continues to have a significant role to play in educating Americans. Measuring impact and evaluating efficacy will continue to be an important part of this work.

To learn more about public broadcasting's commitment to education, visit www.pbs.org, www.pbs.org/teachers, pbs.org/parents or, more importantly, the website of the local public television station in your community.

APPENDIX B

PBS TEACHERLINE STATION PARTNERSHIPS

Arizona—ASSET-Eight/KAET, Tempe

Arizona Teachers Excellence Program
 School Readiness Council, Maricopa County
 CCS Presentation Systems (statewide mobile training labs)
 Qwest Foundation in Education

Arkansas Educational Television Network, Conway

Arkansas Department of Education
 College Credit Partners:
 University of Central Arkansas

Colorado—Rocky Mountain PBS, Denver

Colorado Department of Education, Office of Standards and Achievement Support
 Colorado Department of Education, English Language Acquisition Unit
 Centennial BOCES, Learning Services
 Northwest Consortium for Professional Development
 Colorado Association of Science Teachers
 Pueblo City Schools
 Denver Public Schools, ProComp Office
 Public Television Stations:
 KTSC, Pueblo/Colorado Springs
 KRMJ, Grand Junction
 College Credit Partners:
 University of Colorado at Colorado Springs

District of Columbia—WHUT

Howard University, School of Education
 WHUR-FM

Florida—WLRN, Miami

Miami-Dade School District
 Academica, Inc.
 Public Television Station Partners:
 WXEL, West Palm Beach, FL
 WMTJ, San Juan, Puerto Rico
 College Credit Partners:
 Nova Southeastern University

Illinois—WSIU, Carbondale

Southern Illinois University, College of Education

Indiana Public Broadcasting Stations/WFYI, Indianapolis

Indianapolis Public Schools
 Indiana College Network
 Indiana Department of Education
 Indiana Humanities Council's Smart Desktop
 ISTEM
 Indiana Computer Educators

Public Television & Radio Station Partners:

WTIU-TV and WFIU radio, Bloomington
 WNIN-TV and WNIN radio, Evansville
 WFWA-TV, Fort Wayne
 WFYI radio, Indianapolis
 WYIN-TV, Merrillville
 WIPB-TV, Muncie
 WNIT-TV, South Bend/Elkhart
 WVUT-TV, Vincennes
 WBAA radio, West Lafayette
 College Credit Partners:
 Marian College

Iowa Public Television, Johnston

College Credit Partners:
 Drake University

Louisiana Public Broadcasting, Baton Rouge

Associated Professional Educators of Louisiana
 Louisiana Federation of Teachers

Maryland Public Television, Owings Mills

Anne Arundel County Public Schools
 St. Mary's County Public Schools
 Washington County Public Schools
 Baltimore City County Public Schools
 Archdiocese of Baltimore Private Schools
 Worcester County Department of Professional Development
 Allegany County Public School

Massachusetts—WGBY, Springfield

Hampshire Regional School District
 Easthampton Public Schools
 Massachusetts Department of Education, Office of Instructional Technology
 Public Television Station Partners:
 Vermont Public Television
 Connecticut Public Television
 College Credit Partners:
 Merrimack College
 Westfield State College

Michigan—WKAR, East Lansing

Michigan Department of Education, Office of Early Childhood Education and Family Services
 Michigan 4-C Association
 Ingham County Health Department, Office for Young Children
 Ingham Intermediate School District
 Capitol Area Community Services Head Start

Mississippi Public Broadcasting, Jackson

Canton Public School District
 Leake County School District
 South Delta School District
 Yazoo County School District

College Credit Partners:
Mississippi College

Nevada—Vegas PBS

Clark County School District, Licensed Personnel Department

Nevada—KNPB, Reno

Washoe County School District
Elko County School District
Western Nevada Regional Training Program
Northwest Regional Professional Development Program
Northern Nevada Mathematics Council
College Credit Partners:
University of Nevada–Reno, College of Education

New Hampshire Public Television, Durham

New Hampshire Department of Education
New Hampshire Local Education Support Center Network
New Hampshire Regional Professional Development Centers
College Credit Partners:
Plymouth State University

New Jersey Network, Trenton

New Jersey Department of Education

New Mexico—KNME, Albuquerque

New Mexico Public Education Department Rural Education Bureau
New Mexico Division of Higher Education
College Credit Partners:
University of New Mexico

North Dakota—Prairie Public Broadcasting, Fargo

North Central Council for School Television
North Dakota Department of Public Instruction, State Title I Office
Lakes and Prairies Child Care Resource and Referral
Children and Family Services Division of the North Dakota Department of Human Services
College Credit Partners:
North Dakota State University
Minnesota State University, Moorhead

New York—WNED, Buffalo

Science Teachers Association of New York (STANYS)
Reading/Language Arts Association
New York State Mathematics Association
ECLIPSE Science Coordinators
BOCES Model School Coordinators
New York State Teacher Centers
New York State Department of Education
Public Television Station Partners:
WMHT, Albany/Schenectady
WSKG, Binghamton
WLIW, Long Island

WNET, New York
 WCFE, Plattsburgh
 WXXI, Rochester
 WCNY, Syracuse
 WPBS, Watertown

Ohio—WVIZ, Cleveland

Tri-County Educational Service Center
 Logan County Educational Service Center
 Cuyahoga County Educational Service Center
 Cuyahoga Special Education Service Center
 Greater Cleveland Educational Development Center
 Public Television Station Partners:
 Think TV, Dayton
 WOUB and ETSEO, Athens
 WCET, Cincinnati
 WGBU, Bowling Green
 WOSU/WPBO, Columbus/Portsmouth
 WGTE, Toledo
 College Credit Partners:
 Ashland University
 Cleveland State University
 The University of Akron

Pennsylvania—WQLN, Erie

Northwest Tri-County Intermediate Unit
 Northwest Regional Key (supports PA Early Learning Keys to Quality)

Pennsylvania—WITF, Harrisburg

Capital Area Intermediate Unit

South Carolina ETV, Columbia

South Carolina Department of Education
 Public Television Station Partners:
 Georgia Public Broadcasting, Atlanta
 UNC-TV, Research Triangle Park, NC

Tennessee—Nashville Public Television

Tennessee Department of Education, Office of Early Learning
 Metro Nashville Public Schools
 Public Television Station Partner:
 WLJT, West Tennessee State University
 College Credit Partner:
 Tennessee State University

Texas—KLRU, Austin & KLRN, San Antonio

Texas Computer Education Association
 Texas Education Agency, Division of Advanced Academics/Gifted and Talented
 Public Television Station Partners:
 KACV, Amarillo
 KEDT, Corpus Christi
 KERA, Dallas
 KMBH, Harlingen

KUHT, Houston
 KNOT, Killeen
 KTXT, Lubbock
 KOCV, Odessa
 KWBU, Waco

Virginia—WHRO, Norfolk

Virginia Society for Technology in Education
 Virginia Department of Education
 Public Television Station Partners:
 MHz Networks, Falls Church
 WVPT, Harrisonburg
 WCVE, Richmond
 WBRA, Roanoke
 College Credit Providers:
 James Madison University

Wisconsin Educational Communications Board, Madison

College Credit Partners:
 Viterbo University

BIOGRAPHY FOR ROBERT M. LIPPINCOTT

As PBS Senior Vice President for Education, Mr. Lippincott is responsible for the development and delivery of public media educational programming and services to teachers, students and their parents from PBS through local public television stations. He directs the PBS Teachers websites and a system-wide digital media repository. And he oversees national projects and partnerships including federal grants for PBS TeacherLine, offering online teacher professional development, and PBS Kids Raising Readers, offering programs on-air, online and in the classroom to help early learners read.

Before joining PBS, Rob has served in a wide variety of leadership positions in schools and businesses building and applying media and communications technology to education. He has been a classroom teacher, a member of the faculty of Harvard University, Graduate School of Education and a pioneer in multi-media and Internet design for K–12 audiences.

Most recently, Mr. Lippincott served as Senior Vice President of product development for Discovery Education, the newest division of Discovery Communications, Inc., responsible for the digital video streaming, online and hard copy products developed for the home and school markets. He was President and CEO of the early-childhood assessment company, Children's Progress, Inc. He also served as Senior Vice President and General Manager for the Pearson Education Company, Family Education Network. And he was Director of interactive technologies at WGBH Educational Foundation, Boston's public broadcasting station.

Rob holds a Bachelor's degree from Swarthmore College in Literature and a Master's degree in Educational Technology from Harvard University.

Chair LIPINSKI. Mr. Lippincott, I assure you, it is not just children who enjoy the multi-modal learning there. Dr. Grajal.

STATEMENT OF DR. ALEJANDRO GRAJAL, SENIOR VICE PRESIDENT FOR CONSERVATION, EDUCATION, AND TRAINING, THE CHICAGO ZOOLOGICAL SOCIETY

Dr. GRAJAL. Mr. Chairman, Members of the Subcommittee, on behalf of the Chicago Zoological Society, I thank you for the opportunity to appear before you today.

The mission of the Society is to inspire conservation leadership by connecting people with wildlife and nature. The Chicago Zoological Society operates Brookfield Zoo, one of the top zoological institutions in North America. In addition to being recognized as one

of the global leaders in conservation biodiversity, we are a major cultural attraction with 2.1 million visitors a year and over 90,000-member households.

Just as the witnesses in this hearing, our institution is deeply concerned about the failure of our nation's science education system to stem the declining performance of American students. Just in our case, for example, 20 percent of the high school students in Illinois are below grade level in science. There are multiple root causes for this underachievement in science.

I will focus on four major fronts that we are tackling. One of them is providing science exploration for families and children as they come and visit our facility. The second one is a possibility of very strong science education for teaching by partnering with large school districts, in our case, with the Chicago Public School System. The third one is developing science careers for minorities and under-served communities, and the fourth is the exploration of possibilities to measure and provide metrics for informal learning.

I will briefly mention that zoos provide unique opportunities for everybody to explore the natural world outside the home and outside the classroom. Over two million people visit our zoos a year. We are providing special inquiry comparative level for environmental issues such as climate change and species extinctions.

I also want to mention our education partnerships to build teacher scientists. One of the main problems is the national shortage of fully qualified science teachers. In our area, less than four percent of science teachers actually hold endorsements in science, and I don't think our area is any different than nationwide. But surveys have shown that teachers that have little scientific expertise actually transmit, in direct or indirect means, that lack of confidence to the students, making science seem difficult or unexciting. That problem stems at the very early stages of the classroom life.

We train teachers, and in this case, we tackled a very creative partnership with the Chicago Public School System which is one of the largest and most complex school systems in the country. We have developed extensive teacher training program that starts with developing the basics of scientific inquiry from one-credit hour courses to summer institutes, all the way to science graduate school with several colleges in the mid-west region. This is a major institutional initiative that has included thousands of teachers in Illinois and nearby states in the Great Lakes Region over the last three years, and it is a source of personal institutional pride that these teachers are actually inspiring under-served segments, in particular, school-age Hispanic girls and African American boys when they are finding that science can be a life call and a career destination.

I also want to mention how we are developing a Career Ladder for engagement of minorities and under-served communities. Our society, as many other in the industry, requires a highly trained technical workforce. We have zoologists, engineers, researchers, statisticians, and geneticists with a very strong background. We as an institution have identified diversity as one of the institutional strategic goals, and we decided we cannot take a passive approach in this. We are developing a science-based, lifelong learning starting with thousands of families of prominently African American

and Hispanic neighborhoods with a very dedicated outreach program and developing opportunities for these inner city families to develop nature and science. A camping trip in the Indiana Dunes by inner city families is a lifetime experience that opens new frontiers in developing and understanding the natural world and inspiring new careers in science.

Once these children move to high school, we are developing a youth science conservation leadership program that develops professional preparation schools that includes a dress code, engaging the public speaking skills, team building, in addition to carrying independent science projects. So they actually carry these projects at the very early age in high school.

We are developing also metrics for measuring informal science education. As a major provider of informal science education, we have helped to create the emerging field of conservation psychology, the scientific study between the reciprocal relationship between humans and nature. Our research questions are addressing how humans care about nature and how do they engage, and psychological factors that affect the engagement of humans in science.

Perhaps also one of the most pervasive obstacles are the lack of common standards and benchmarks for measuring informal science learning and education. Just as other panel members, we really are really needing these psychological metrics for developing personal comfort and confidence in applying this education. We call actively for this partnership to develop these benchmarks and indicators.

Mr. Chair, thank you again for the opportunity to appear before this Committee, and I would be happy to answer some questions. Thank you.

[The prepared statement of Dr. Grajal follows:]

PREPARED STATEMENT OF ALEJANDRO GRAJAL

Executive Summary

The Chicago Zoological Society is a global conservation organization committed to expanding the role of informal environments in educating students and the public about Science, Technology, Engineering and Mathematics. Declines in participation in science education by students and the public have multiple root causes. To stem this decline, the Chicago Zoological Society is focusing on three major fronts:

- Providing fun and exciting opportunities for science exploration by families and children;
- Developing strong science training opportunities for teachers through creative partnerships with formal education systems, such as the Chicago Public School System; and
- Developing a science career ladder for youth and young professionals for traditional under-served communities and minorities.

As a result of these efforts, the Chicago Zoological Society has:

- Helped raise the competency and confidence of Chicago-area teachers in the field of science education;
- Worked to combat low minority representation in highly-technical workplaces and the lack of scientific role models for students in highly-urbanized, economically distressed areas;
- Engaged youth from early childhood through college to position them for academic and professional growth in science, mathematics, engineering and technology; and
- Developed a new field of study; conservation psychology.

The need is large and the stakes could not be higher: investing in informal science education is crucial to maintain the world leadership position of the United States

in science education. Federal funding, such as the *American Recovery and Reinvestment Act*, correctly included some funds to continue innovation for science education. Unfortunately for the Chicago Zoological Society, the bill also included a provision prohibiting zoos from accessing or even competing for economic stimulus funding. As Congress continues its deliberations, please consider the consequences that zoos across our nation will face if they are unable to improve and modernize their aging infrastructures. At Brookfield Zoo, we stand ready with a number of worthy, well-planned and much-needed infrastructure projects that will create jobs, help local small business owners and contribute to the economic recovery of our nation.

Mr. Chairman and Members of the Subcommittee, on behalf of the Chicago Zoological Society, I thank you for the opportunity to appear before you today. My name is Alejandro Grajal, and I am Senior Vice President for Conservation, Education and Training at the Chicago Zoological Society, based in Brookfield, Illinois.

The mission of the Chicago Zoological Society is to inspire conservation leadership by connecting people with wildlife and nature. We define “conservation leaders” as any person who acts on behalf of the environment and influences others to do so. Our goal is to create conservation leaders among our guests, our community members, and people around the world.

The Chicago Zoological Society operates Brookfield Zoo, one of the top zoological institutions in North America. In addition to being recognized as a global leader in the practice of animal care and well-being, Brookfield Zoo is our state’s most popular outdoor cultural attraction, with 2.1 million annual visitors and 90,000 member households.

Brookfield Zoo is also an economic engine that pumps more than \$150 million a year into the Illinois economy while supporting 2,000 jobs.

While we are certainly proud of our roles as a global conservation leader, economic engine and top tourism attraction, we are particularly pleased with the impact that our award-winning conservation programs have had in the lives of children throughout Chicagoland.

As a leading provider of informal science learning for families, school districts, and universities in the region, the Chicago Zoological Society is working with teachers, students, parents and school administrators to usher in a new era of informal education.

Just as the other witnesses at this hearing, my institution is deeply concerned about the failure of our nation’s science education system to stem the declining performance of American students. Middle school and high school students are consistently out-performed by their peers in other developing nations.¹ The long-term impact on individual and national success in the 21st century is imminent: a mere 15 percent of United States undergraduates are majoring in science or engineering compared to 47 percent in France, 50 percent in China, and 67 percent in Singapore.²

Science literacy is also a significant challenge in Chicago and Illinois. Although the percent of students participating in public schools in Illinois has shown gains in performance in science based on standardized test scores in recent years,³ slightly more than 20 percent of public-school students statewide are below grade level in science as measured in 4th and 7th grades. Furthermore, the percent of students not reaching grade level far exceeds this percent at many individual Chicago Public Schools in Illinois.

While student’s underachievement in science has multiple root causes, we at the Chicago Zoological Society are focusing on three major fronts:

- **SCIENCE EXPLORATION FOR FAMILIES AND CHILDREN:** Zoo visits provide an inquiry-driven experience every day, through a fun and personal exploration of science by families and children
- **TEACHERS’ SCIENCE CAPACITY AND CONFIDENCE:** Developing creative partnerships with formal education systems, such as the Chicago Public School System, allows us to focus in providing science training opportunities for teachers

¹*Toward a Systematic Evidence-Base for Science in Out-of-School Time: The Role of Assessment*, Hussar, Karen, Ed.D., Schwartz, Sarah, M.Ed., Boisselle, Ellen, Ph.D., Noam, Gil G. Ed. D., Ph.D.

²Augustine, N.R. (Chair). (2005). *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. National Academy of Science, National Academy of Engineering, Institute of Medicine. Washington DC: National Academy Press.

³Illinois State Achievement Test results 2007.

- **CAREER BUILDING OPPORTUNITIES FOR UNDER-SERVED COMMUNITIES AND MINORITIES:** Developing a science-based career ladder for youth and young professionals for traditional under-served communities and minorities with the specific objective of increasing the diversity of views about science and the natural world.

Engaging Zoo Visitors in Scientific Discoveries

Zoos provide unique opportunities for everyone to explore the natural world, develop inquiries about animals and habitats, and experience science outside the home or the school. A day at the zoo is a fun, family experience in a friendly environment. Recent psychological research has demonstrated that a walk in natural open settings significantly 'resets' higher skills in math and reading skills.

A family day at the zoo is a personal tour for active science exploration of major environmental issues such as climate change and species extinctions.

Our immersive exhibits with live animals in naturalistic settings incite exploration and self-paced learning. For example, we provide more than 300 zoo chats a week by keepers, scientists and interpretive staff. Applying the latest developments in active inquiry and comparative science, we are transforming our zoo to become a personal tour for active science exploration of major environmental issues such as climate change and species extinctions. However, the science experience does not end beyond our fence: we continue to communicate science information to the general public and our members through our magazine, website, electronic newsletters, and public events.

Innovative Education Partnerships to Build Teacher Scientific Capacities

A second strong institutional direction is our active partnerships with formal education systems. One of our partners is the Chicago Public Schools. Initially a daunting challenge for our institution, our relationship with the Chicago Public School System has developed into an exemplary effort because it operates one of our country's largest and most complex school systems. Chicago mirrors a national shortage of fully-qualified science teachers: only one percent of Chicago Public Schools K-12 teachers hold an endorsement in biology and only two percent hold endorsements in environmental science. Overall, only four percent of the system's science teachers hold endorsements in science.⁴ This problem also includes secondary and post-secondary education.⁵

Illinois teachers ranked "knowledge and application of scientific inquiry" and better application of "how living things interact with each other and the environment" as their highest priorities for professional development in science.

Limited teacher skills in science go beyond actual content knowledge: Illinois teachers ranked "knowledge and application of scientific inquiry" and better understanding and application of "how living things interact with each other and with their environment" as their highest priorities for professional development in science. Working with Chicago area school districts, we have developed an extensive teacher-training program in which we provide sequential levels of engagement in science for these teachers, from one credit-hour courses, to summer learning institutes, all the way to graduate school in Advanced Inquiry skills. Our program Levels of Engagement is an inclusive learning process that emphasizes raising the competency and confidence of teachers in science education.

One of the great advantages of informal learning institutions is that we are not bound by rigid assessments of content milestones. Therefore, we emphasize the measurement of inquiry skills, comparative scientific method, critical thinking, and competence and confidence in teaching science. This is major institutional initiative that has included thousands of teachers in Illinois and nearby states during the last three years.

The potential impacts in working with a large urban system like Chicago can be significant. For example, although 78 percent of the participants were certified by the Illinois Board of Education, less than eight percent had an endorsement in

⁴ www.learn.niu.edu/ISBE2005

⁵ Raizen, S., & Michelsohn, A.M. (1994). *The future of science in elementary schools: Educating prospective teachers*. San Francisco: Jossey-Bass.

science. Nearly half of our participating teachers work at schools with 90 percent or more low-income students. Furthermore, nearly half of the schools that we work with were on the 2007–08 State Improvement Status list with at-risk potential.

These young adults overcame their reluctance toward science and asked “What does it take to work at Brookfield Zoo?” They realized that a science-based career can be part of their future, an important attitude turning point for this highly diverse group of students.

Beyond the numbers, it is a source of personal and institutional pride to see traditionally under-served segments, such as high school-age Hispanic girls or African American boys discovering how science can be a life call and a career destination. Last Spring 25 students from Chicago High School for Agricultural Sciences, one of our partner Chicago Public Schools, spent a day at Brookfield Zoo shadowing staff in 11 areas of the zoo, including the genetics, physiology and nutrition labs, and animal hospital. Several of these young adults overcame their reluctance toward science and actively engaged in spirited questions, such as “What does it take to work at Brookfield Zoo?” and “How do I become one of your professional staff?” They realized that a science-based career can be part of their future, a professional turning point for this highly diverse group of students.

Beyond our engagement with school districts, we also see a fertile ground for partnerships with colleges and universities. Our university-level partnerships include programs with Aurora University, Benedictine University, National Lewis University, Loyola School of Medicine, University of Illinois, Miami University in Ohio, Chicago State University, and Morton College.

Chicago Zoological Society's Career Ladder Opportunities for Under-served Communities and Minorities

A third and pervasive problem in science education is the low minority representation in the workplace, and lack of scientific role models for under-served students. The Chicago Zoological Society requires a highly trained, technical workforce that includes zoologists, engineers, researchers, statisticians, geneticists, and other positions requiring strong science backgrounds. The lack of science-trained professionals in the zoo industry is similar to that experienced by research labs and science-driven corporations nationwide. But several years ago we realized that we cannot take the passive approach of waiting for these professionals to show up in the marketplace. So we have started a systemic approach at nurturing a diverse cadre of future science, technology and engineering professionals, starting at an early age and providing career—building opportunities at critical life junctions.

We believe that as a cultural institution we should be an active participant and an agent for change in providing these opportunities. Our proactive approach is the Career Ladder for Youth program, which was awarded the prestigious Institute for Museum and Library Services Medal in 2008. This program starts by developing after school programs at Chicago Metropolitan Libraries. We engage thousands of families with young children in predominantly African American and Hispanic neighborhoods. Families and children experience nature, discover science skills at the library and we support trips to the zoo, nearby forest preserves, and the shores of Lake Michigan.

For most of these inner city families, a camping trip to the Indiana Dunes National Park is a once in a lifetime experience that opens new frontiers in understanding the natural world, and inspiring new careers in science.

Once these children move to high-school age, they are eligible to participate in our Youth Volunteer program, one of the largest and most competitive science-driven youth volunteers programs in the state. Our selection process does not take into consideration school grades alone, but also weights the value of cultural diverse backgrounds, abilities in other languages, overcoming social and cultural obstacles, enthusiasm for science and personal drive. The end result is an economically and culturally diverse group of over 150 youth every year that give the zoo over 100 hours of volunteering service.

Career Ladder for Youth participants learn crucial professional preparation skills that are not taught frequently at school, including dress code, engaging the public, speaking skills, team building and how to carry an independent science project. Working with mentors at the Chicago Zoological Society, youth volunteer science projects include public perceptions, genetics, animal behaviors and a wide range of ideas. We also coordinate a meeting with many other cultural institutions in the

greater Chicago region that have active youth volunteer programs, and this is rapidly becoming the preeminent youth scientific fair in the region.

Real-life internships and work-study opportunities, as well as relations with professional mentors and scientific role models, are essential stepping stones in the development of science career paths for minorities.

Our Career Ladder effort does not stay just at high school. Once a young person decides to pursue a university education in science, it is necessary to provide internship opportunities, professional developments and clear career paths beyond the university system. For one, it is essential to provide paid internships to continue to attract minorities that otherwise are shifted away to other careers with perceived higher financial rewards. We have strengthened our alliances with over six universities in the region, and particularly with historically black colleges, such as Chicago State University, and with colleges with strong Hispanic populations, such as Morton College.

This economic recession has increased the need for these professional internships, as many young professionals want to remain engaged in science careers. Career Ladder internships not only provide opportunities but also attract role models in the highly technical and science positions that are needed in our institution.

MEASURING THE EFFECTIVENESS OF INFORMAL SCIENCE EDUCATION

As a major provider of informal science education we are taking deliberate steps in developing good metrics to evaluate informal environments. The Chicago Zoological Society helped to create the emerging field of Conservation Psychology, the scientific study of the reciprocal relationships between humans and the rest of nature. Using an exciting blend of social and natural sciences, conservation psychology has a strong mission focus related to biodiversity conservation and environmental sustainability. Our research questions address how humans care about nature. We also study how humans behave towards nature, with the goal of creating durable individual and collective behavior change. Such approach has allowed us to develop important metrics that go beyond the traditional measures of scientific content knowledge. We are currently exploring further into the realm of personal competence, confidence in science, and how professional skills lead to behavior changes toward the environment.

Informal science education metrics should go beyond the traditional measures of scientific content knowledge and explore measurements of comparative inquiry skills, problem-solving abilities, and psychological metrics in applying science skills to real-life decisions.

But as exciting as this research can be, we are also finding major barriers to developing metrics for informal learning. Perhaps one obstacle has been the over-reliance on technology as a metaphor for scientific progress. We find that informal science instruction tends to overemphasize the use of complex technical tools, assuming that advanced apparatus give us better results. But such approaches tend to overlook that one of the basic components of effective science is the development of strong inquiring questions that translate into clear hypothesis and comparative studies. We advocate for a balance in measuring scientific skills within the realm of comparative inquiry and problem-solving.

But perhaps one of the most pervasive obstacles is the lack of common standards or benchmarks in measuring comparative inquiry skills, problem solving abilities, or psychological metrics to measure level of comfort and confidence in applying science skills to real-life decisions. We actively call for partnerships with other institutions of higher learning and informal science peer institutions to develop case studies and common benchmarking indicators toward effective science education.

CONCLUSIONS

- Institutions such as the Chicago Zoological Society can play an important role in STEM because they engage families and children at an early age. Each day at Brookfield Zoo we help break early barriers to science education: We make science exploration and inquiry as a fun, self-learning experience that can stay for life.
- Institutions such as the Chicago Zoological Society can engage the formal education system through partnerships and provide crucial inquiry skills for math and science teachers. The teachers who participate in our programs be-

come science leaders that are capable of providing innovative and high-quality lessons to their students.

- Institutions such as the Chicago Zoological Society can actively promote and support science career paths for students from under-served urban and rural communities by engaging them early and providing them clear opportunities. We are currently providing these students with career options and training through high school, college and professional skills such as internships and work study opportunities at crucial life junctures.

The need is large and the stakes could not be higher: Investing in informal science education is crucial to maintain the world leadership position of the United States in science education. Federal funding opportunities through legislation such as the *American Recovery and Reinvestment Act* correctly included some funds to continue innovation for, among other things, science education. Unfortunately for the Chicago Zoological Society, the bill also included a provision prohibiting zoos from being eligible to even compete for funding. As Congress continues its deliberations, it should not prohibit or otherwise restrict any qualified provider from eligibility for federal funds because the ultimate impact is that such restrictions prevent our institutions from being part of the solution.

Mr. Chairman, thank you again for the opportunity to appear before the Subcommittee and I am happy to answer any questions.

BIOGRAPHY FOR ALEJANDRO GRAJAL

Dr. Alejandro Grajal is Senior Vice President for Conservation, Education and Training at the Chicago Zoological Society. In this position, he oversees a unit that combines the Society's major conservation programs with education and interpretation initiatives and develops the capacity of conservation leaders in Chicago and around the world. He oversees field programs, conservation grants in more than 20 countries, including the development of develops training programs for Latin-American conservation professionals. He also oversees all aspects of the Brookfield Zoo education and interpretation programs, which impact two millions visitors yearly and serve more than 250,000 school children annually. The unit organizes education programs for families and children, summer zoo camp, and access programs for people with disabilities; create exhibit interpretation and messaging throughout the zoo; manage community outreach ventures, and develop benchmarks as part of our audience research program, including the innovative field of Conservation Psychology. In addition, he guides several initiatives to widen the Society's leadership in programs that build conservation capacity, such as the Youth Conservation & Science Leadership program. Prior to joining the Chicago Zoological Society in 2005, he was the founder and Executive Director of the Latin America and Caribbean program of the National Audubon Society. While there, he worked with more than 50 partner organizations in 15 countries around the world. Prior to that appointment, he was Director of the Latin American Program at the Wildlife Conservation Society in New York from 1991 to 1998. He was born in Madrid, Spain, and moved as a child to Venezuela. He received his undergraduate degree in Ecology at Simon Bolivar University in Caracas and his Ph.D. in Zoology with a minor in Tropical Conservation and Development at the University of Florida. He has participated in protected area planning and conservation programs with the United States Agency for International Development, the Global Environmental Fund, the World Bank, and the European Union. His publications include over 30 peer-reviewed books, chapters, popular articles, and scientific publications. His scientific interests include ornithology, biological conservation, environmental education, training of conservation professionals, and the sustainable use of natural resources. Dr. Grajal has explored public perceptions, social psychology, and marketing techniques. He is an accomplished wildlife artist with over 30 published illustrations in books, calendars, stamps, posters and limited edition prints. His art has been exhibited in galleries in Caracas, Miami, Chicago, and New York. He is married to Dr. Helena Puche and has two children.

DISCUSSION

Chair LIPINSKI. Thank you. I would like to thank all of you for your testimony. I am going to open up for the first round of questions, and it is the Chair's prerogative to go first, but I am going to recognize Mr. Griffith for five minutes.

Mr. GRIFFITH. Mr. Chair, thank you very much. We appreciate each and every one of you coming. I would like to make just a comment. I am a retired oncologist but a tadpole changed my life, and the transformation, watching the tadpole become a frog and have my little brother ask me how did it know to do that, stimulated me into a career of being interested in science.

One of the things that I think that we sometimes maybe overlook and probably not overlook but in all fairness to what we are trying to accomplish here, my great question for America is that why aren't our children learning to read? Why aren't they reading at grade level by the third grade? Because they learn to read and then after the third grade, they read to learn. And you may be seeing children that your teachers can teach, but you are not seeing a great many who we have lost along the wayside. So I commend you. I think that the great question in America, because we only represent six percent of the world's population, yet we are number one in space travel, we are number one in military, we are number one in the development of drugs, and entrepreneurialship, means that you have your work cut out for you because the statistics that we don't think that we are the leaders anymore in some of those areas are wrong, but we are getting that feeling at times. But I applaud you and thank you for being here and our Chair for bringing this subject up. Thank you.

Chair LIPINSKI. Thank you, Doctor, and we look forward to your contributions to this subcommittee. I will now recognize Dr. Ehlers for five minutes.

Mr. EHLERS. Thank you, Mr. Chair. I really appreciate your testimony. It is very interesting. I grew up in a farming community, and it was amazing how much of the science that students learn was learned on the farm. Obviously they learned about pulleys and levers in the farm work, trying to get the hay in the mound, et cetera. They learned a lot about the life sciences and the reproductive cycle and genetics in their work on the farm by watching the animals. And that is missing today.

I am just wondering what—first of all, Dr. Bell, in the work that you did in the report, did you go back and look at prior years and see what the difference was today between informal education and what it was 30 years ago, 70 years ago, et cetera?

Dr. BELL. Thank you for the question. We went back in the literature as far as we could. One of the challenges with doing the consensus studies, informal science education is such a broad variety of different endeavors as we have been hearing across the panel, and you can think of community programming for youth and kind of layer on even more than we have been able to talk about thus far. We had discussion about generational shifts from kind of over the last 50 years, and one feature that is really unique of informal learning environments is that you get mixed generational groups together engaged in discussions of science. And so in that sense, people that did grow up on the farm but now reside in the city can engage in conversations with their children and grandchildren, and perhaps they are a docent at a museum and they can engage with the public more broadly around related aspects of the expertise they have been developing.

That said, we also were orienting to a number of efforts that are organized across the country where farming and subsistence agriculture is still, you know, a focus of community life and activity. And so we are looking at evaluation reports of 4-H programs and those sorts of endeavors.

And so to some degree, we did try to capture that in the report. What I would say is that we wanted to articulate, as we looked across the literatures, this shared image of science learning across six strands that we identify, and two of them are particularly important to informal learning environments around the prior interest that get cultivated. And I think we have already started to hear a number of those stories. The tadpole story is exactly of that kind. And then over time how that learning gets sustained by a range of others in your life and accessed experiences that sustain it and keep it deepening. And then you come to identify with science and see that you can learn from it and contribute to it, and those two particular dimensions are very strong within the work, within the informal world. So that is a bit of a response.

Mr. EHLERS. Thank you. Dr. Ferrini-Mundy, can you just give some insight into how informal science education supported research at the NSF differs from other education and human services research or human resources research?

Dr. FERRINI-MUNDY. Yes, certainly. Thank you very much for the question. In many ways the research questions that have to do with informal science learning overlap substantially with research questions that have to do with learning in a general sense. Your last question actually caused me to think about a whole line of research in my own field, in mathematics education, that looks at everyday uses of mathematics, everyday mathematics. And sometimes in other countries, children who are street vendors or candy-sellers, there have been really interesting studies that have looked at how mathematics gets used in a day-to-day way in similar studies in science. And so that's an example of a line of research that bears upon informal science education, but that doesn't necessarily come up through the informal science education program. So we have several programs within EHR and elsewhere in the Foundation that fund basic research about learning, that fund programs to look at motivation and engagement which are some of the fundamental questions here, and then the relationships of motivation and engagement to learning, to long-term impact and so forth.

So it is fair to say that both the informal science education program itself, which includes opportunities for research on learning, but also the formal learning kinds of programs like Research and Evaluation on Education in Science and Engineering, the REESE program, also is a place where there are a number of studies that bear upon these general cognitive and affective issues that are of great interest for moving forward in informal science education, along with the development of instruments which is, as we have heard from everyone, a crucial place, and that occurs across programs.

Mr. EHLERS. Yes, well, I admire the work you are doing and I deeply appreciate it. That is true for all of you, but it seems to me it is very hard to get a handle on these things. Part of the problem is the rapid changes in society. You know, what you are doing, Mr.

Lippincott, is a good example of taking a new technology and using it very well. At the same time, kids miss out on some other things. I recall in my childhood I really enjoyed working on the cars, and they were simple enough that you could work on the car and fix it yourself. I did a valve job on my car myself. Today, you don't even dare to touch anything on a car. It will take \$1,500 to repair the damage you did. And similarly, the computers are marvelous things, wonderful things for kids to use, but they can't take them apart and see how they work. And so I think we face some real challenges in trying to address those issues. I see my time is expired.

Chair LIPINSKI. Yes, interesting ideas there, and I know that especially, my background is mechanical engineering, so I have a much better understanding and I guess more of a love of mechanics. So I do understand Mr. Ehlers' concerns there about what we can do now.

I am going to now recognize Mr. Carnahan for five minutes.

Mr. CARNAHAN. Thank you, Mr. Chair, and Ranking Member. I come from St. Louis, Missouri, and we are blessed with the wealth of science and engineering institutions there which we are always looking for great opportunities to plug kids into and get them excited at an early age because of the practical benefit to those kids but also they are the next generation of people who are going to be those scientists and engineers to fill in those great public and private institutions that we have around the St. Louis region. But my question is to the panel, what are the key factors in really forging a successful partnership between the informal organizations and formal educational institutions, and is it hard to quantify those measurements? Are there metrics out there that exist? Are there barriers to measure that in terms of how we assess what works well? And really, to any and all the panel.

Ms. INGRAM. May I answer? Thank you for the question. Let me address at least part of that which is that, and I think this relates back to the prior discussion, which is how do we overcome kind of the distance that technology might have imposed between, you know, the inspiration and inquiry that was generated in prior generations to propel the interest in science, and that is the opportunity that we have from that technology, however, is to better coordinate and align the external resources that do exist and coordinated efforts like we have undertaken in Chicago through Science Chicago and hopefully some additional work to really partner, identify the resources that exist, identify how those resources align with the learning standards and the curriculum that our schools are trying to instill in our youth, and to make those resources transparent and accessible to the families, communities and teachers who can access them for the benefit of our youth.

So to the extent that there is a lot of great programs out there, we have this additional significant barrier of making sure that people know what those programs are and how to access those programs. That takes significant coordination and partnership in and of itself. How you measure that, if you coordinate that through a website, there are ways of doing that. You can build in management tools to make sure that it is being used, that the conversations are happening, that the connections are being made. But you

have to partner, you have to work closely with your local school districts, you have to make sure you understand what they are trying to accomplish in the classroom and that resources are reflective. The one thing that you can't do is assume that external resources are just going to immediately adopt the strategic vision of your local school district. It has to be a shared objective and shared strategic visions, and we have to build our programs to support that outcome of science achievement or we won't be able to have that impact. Thank you.

Mr. CARNAHAN. Thank you.

Dr. BELL. Within the bounds of the report, we were looking at a range of different kinds of articulations between schools and science-rich institutions in the informal sector. The first point to be made, there was a time and place where the idea that informal learning was something different than formal learning, that might have been a conversation. The Committee didn't end up there. The Committee ended up actually saying there is a shared set of goals related to science learning that we can think about what the unique contributions are to be made in schools versus other places where, you know, within the informal education sectors. That is kind of more the centerpiece. We looked at field trip studies because school groups do make extensive use of museums and botanical gardens and zoos and aquaria, and you know, the research points to the important articulation between the goal of those, you know, experiences outside of school in relation to what is being learned in school, both before the visit and after the visit. At the same time, it can be active involvement of the teacher in planning those efforts. The teacher isn't backing away from the activity once they show up at the museum.

What was interesting is there is a widespread thing that museums and informal learning institutions also engage in. teacher training, but there isn't an empirical peer-reviewed research literature on how that plays out actually. So we couldn't speak to the details of the quality of those experiences, and it is an established gap in the literature.

Mr. CARNAHAN. Thank you.

Mr. LIPPINCOTT. I wanted just to address it if I might. I think in terms of public television, for instance, I have talked a little bit about how we kind of are perfectly aligned with what might be called strand one of Dr. Bell's research around gathering interest and motivating interest in science. When we have tried to work much more deeply with teachers and schools, because of course, the real gold standard is that if kids are truly interested in it, we can show their achievement so that for instance our TeacherLine courses required us to partner because we have to be really relentlessly humble about really what impact our television or media might have in the actual classroom. So we partner. We have 23 institutions that grant credit because of course that is their role, and it is aligning with their interest that allows us to be effective and also with hundreds of local organizations in every city in St. Louis, in Chicago, and across the country who are the point of service, meaning, really the 4-H Clubs and the Boys and Girls Clubs as well as in the city schools. The degree to which we can conform our goals for the program to the goals of learning achievement that

have been set by local standards, that is the degree to which we are successful. Trying to get that entire sort of life cycle of an idea understood and measured is the really tricky part. What we have been trying to do is trying to talk about how each piece of what we are creating has a set of research around it and we can prove that it is well-crafted, it is based on scientific research, and that it will work. We also want to prove that the way we are using teacher professional development, the process that we are using, will result in increased confidence and competence of teachers using media. And of course, the ultimate test I think of a partnership is that it continues.

Mr. CARNAHAN. Thank you.

Dr. GRAJAL. Just if I may add, we receive almost 250,000 school children in our zoo. I mean, at the season it is a flood of yellow buses in our facility. We have decided we really need to focus on teacher training. It is an issue that we can get as many children in our facility, but truly teachers are one of the key roles.

And seconding Dr. Bell's testimony is the issue of competency and confidence in teachers, that it really percolates through the classroom. A teacher that is unsure about his or her credentials in science or even exploring science, it doesn't matter if she is accredited to it, it transmits that insecurity to the classroom. So one of the issues that we are measuring with our six partner degree granting institutions, six colleges and universities that we are working, is actually developing indicators for that confidence and that competency in teachers. We believe that that is one of the stem roles of our facility. And developing that very basic inquiry, comparative inquiry skills in teachers. There is grave emphasis now on technology and issues about advanced science, but we have lost what Mr. Ehlers presented is that inquiry that happens in the farm, that comparative issues that happen when you are in the field, and we believe that that is somewhat lost. We really want to instill those very early stages of the comparative inquiry in teachers. And that is the root of many of the training that may happen for teachers. Thank you.

Mr. CARNAHAN. Thank you to the panel, and thank you, Mr. Chair.

Chair LIPINSKI. Thank you. It certainly is a critical part of this, is the putting together the informal in the formal education.

I am now going to recognize myself for five minutes. Plenty of questions here, but I want to start out, we were just talking about—a lot of this was relationships, partnerships with schools. I want to ask about partnerships with institutes of higher education, partnerships with industry, partnerships with National labs. Last Congress I introduced a bill, and I am working again on doing that in this Congress, to authorize funding for partnerships between science museums and energy labs so that we can better utilize the resources, the knowledge, what we are doing putting into energy labs to help teach STEM education which also will help educate people, not just educate in STEM education but also educate them about what is going on and the investments we are making in our DOE labs. I just wanted to throw that question out there. What other partnerships do you have or that you know of between these

informal education institutions and some of these other institutions? Doctor?

Dr. FERRINI-MUNDY. Thank you for the question. In many of our funded projects, there are partnerships with institutions of higher education, particularly around these research issues because the involvement of cognitive scientists, STEM disciplinary education researchers, sometimes sociologists, anthropologists and so forth, those become a part of this as well as of course the scientific expertise that is crucial in these kinds of co-funded efforts. So we have a number of examples, and I can get back to you with some specific examples.

We also have examples of some collaborations that are coming through the National labs and other kinds of settings. I was just looking at a project today about helping to improve students' understanding of the scientific experiments at Fermilab. And so we have examples in many cases where these partnerships are crucial because this field is so broad in its span that it requires lots of kinds of experts to move it forward well.

Chair LIPINSKI. Dr. Bell.

Dr. BELL. I can give one personal example, so I am kind of taking off the Committee hat in terms of the consensus report, but we have funding from the National Science Foundation through the COSEE program, the Centers for Ocean Sciences Education Excellence, that has brought together, at the University of Washington's Seattle area, scientists in ocean sciences together with folks like myself that are learning scientists together with informal education experts at the aquarium to engage the broader citizenry in citizen science activities related to issues that are kind of local but scientifically rich questions about land-water interaction, and kind of our individual behaviors that we make choices in daily life and how that impacts the environment. Through a sustained, multi-year effort, these different groups have been able to productively collaborate, and how do you engage a broad network of citizens in helping better understand this issue by collecting data and samples from across a broader variety of places that then come to the University of Washington to be analyzed more directly. So there is a ripple effect there as well where I have learned a lot more about science through that endeavor. Our collaborators in ocean sciences have changed the way that they do their teaching on the campus in relation to knowing more about how people learn as well, and I think that is kind of a concrete instance of what can be done in those sorts of partnerships.

Ms. INGRAM. In addition to the generalized type of partnership and coordination that I mentioned earlier as being imperative, let me share with you a couple of specific examples where the museum and the youth that we serve have benefited from coordinating with higher learning and our National laboratories. One is in our Institute for Quality Science Teaching. It is important to our school district that their science teachers become credentialed, and it is important to us and to our youth and to the teachers that they become credentialed in a quality manner so that their performance actually has an impact on the student achievement. So in helping the Chicago Public Schools reach their goal of having every teacher subject matter credentialed in science in the middle grades within

the next two years, we have had the advantage of having partnered for the last two years with a couple different universities to try out what programs might work to support teacher professional development.

So we have worked with National-Louis University, Loyola University Chicago, as well as the Illinois Institute of Technology. IIT, by way of example, we are building a jointly credentialed program. Our programs target teachers who are not comfortable teaching science but find themselves in science classrooms. You can't learn or inspire youth if you yourself have no confidence in the subject matter. So we focus on building that confidence and the competency and the content as well as the teaching strategies. So we have a pool of teachers, 128 annually, who are with us in a program that can earn them three credit hours, and these are teachers that would not sign up with IIT for a science credentialing program because frankly they never had it in their professional future to be science teachers. But because we have built the access, we have partnered with IIT to offer low-cost credit hours, they find themselves moving from not touching it with a 10-foot pole to having three hours toward an 18-hour credential by the end of the year. And then they get to sign up for another workshop with us the next year, and all of a sudden they have six. So what we are trying to do is to build access to that pool of teachers that don't even dream of themselves as being science but find themselves teaching it anyway and to build that pool toward being the competent subject matter science teachers.

The other quick example in partnership is with Argonne National Laboratories. In our Fab Lab which is a really great, hands on where the kids can come in and design and fabricate all sorts of different things from furniture to electronics to key chains, and in doing that, we don't necessarily have the technical competency around the software and the evolution that our MIT partners would require but Argonne does, and they have been a partner from the beginning with us. So we get to have youth from our youth development program, the science achievers, participate every Saturday morning with the support from volunteers from Argonne National Laboratories who now have taken ownership of that vision, the work, that can be done, to extend access to that technological and engineering learning in the museum. So there are a lot of opportunities, but it takes working together to find where your common interests are so that we can access the scientific competencies of Argonne scientists but then help bridge it to the youth that want to be inspired by it.

Chair LIPINSKI. I would like to come there and use the Fab Lab. Sounds like a lot of fun.

Ms. INGRAM. You are more than welcome, and it really is.

Chair LIPINSKI. Mr. Lippincott.

Mr. LIPPINCOTT. Just as a quick example, I showed you a little bit, just a smidgen, of STEM science resources that we are trying to gather as part of EDCAR. We started on that project by trying to figure out where we could contribute the most, and we asked that question of a broad variety of students and teachers and school systems and universities. And most people said STEM, and in fact, most people said within the STEM, they wanted Earth

science which is such a pivotal part of the sequence of learning science in school and a bump in the road for a lot of kids. Within Earth science, climate science. And we asked why, and it is because kids are so excited, they are so interested in climate science. They all know about weather, and they all hear about things on the news and they are all interested but also puzzled. The more we looked at this, the more we needed partners. And so we went certainly to the NSF who have been a great partner for us in many ways. The STEM digital library is an outstanding collection of materials that now we think we can help present. But we needed the curriculum, so we went to NOAA which has produced a very carefully mapped strands of the science curriculum for climate science, and of course, we went to school systems where in fact school systems in every state have standards and have exact standards about which part of the science curriculum they need to learn. We have been actually working with the CCSSO, the Council of Chief States School Officers, who are after what they call fewer, higher, clearer, maybe perhaps national standards at some point about this.

But clearly, in order to get to kids in the area that they said they are most interested, we have to help teachers because they told us even if they have advanced degrees in science, let alone are challenged by not thinking of themselves as scientists, they don't know how to teach this science. They don't really know what this science—and they don't have the resources. They look in their textbooks and there is not very much in that chapter. And so we felt like that was a place to start. So by working through partners like this, we can go to where the science is best, we can really help science teachers where they really need it the most and where we think actually media has a really appropriate role to play, not substituting for field experience but really amplifying what teachers need.

Chair LIPINSKI. Thank you.

Dr. GRAJAL. Just one, simple example is that we are now launching our second graduate degree, Master's degree, for science teachers actually. Many of the graduate programs for teachers have been in education. We are trying to develop these science degrees for teachers, and there is quite a market for that. Teachers are truly interested in this.

Our first experiment was a consortium between Fermilab, Morton Arboretum, Brookfield Zoo, and Benedictine University, and now we are launching a national program with Miami University in Ohio that is bringing five zoos in the country. It is an advanced inquiry program that develops basic scientific inquiry skills for teachers that really want to jump into that level of scientific training. And it is about teaching science but also pedagogical tools for teaching science. Thank you.

Chair LIPINSKI. Thank you. Thank you for your extensive answers. I think the partnerships are really critical in forming those, and all of you head over a lot of different areas and a lot of different partners, and I think that is something we need to work on also on the federal level and see what we can do to encourage more of that.

We are joined by another new Member on the Subcommittee, and I will recognize Ms. Fudge for five minutes.

Ms. FUDGE. Thank you, Mr. Chair. I would like to thank all of you for being here today, and I do have just a couple of questions after I make a brief comment. I want to first share with you that on Friday of last week I had the opportunity to attend the grand opening of our first STEM school in the city of Cleveland. It is called MC2 STEM. The thing that is exciting about it is that it is actually housed in General Electric's lighting division, Nela Park Campus. Obviously, the setting of the school creates some of just what we are talking about today, I mean, because the young people will have an opportunity to, on a weekly basis, have lunch with engineers, with scientists, they will have hands-on experience. So we are talking about the same kinds of things that you are talking about today. But I guess my question really becomes that, in the City of Cleveland if you are not familiar with our area, it has been deemed the number one or two poorest city in America for the last three years. What happens to the young people who don't have the resources to attend the zoo or to go to the science center or to go to museums if their schools do not take them? And most of the schools don't have the resources either. So I am really looking at how we address the issue of under-served youth. MC2 STEM is wonderful, but it is a very small group of children. How do we get to the rest of them? That is my first question, and that is for anyone on the panel.

Ms. INGRAM. If I may briefly answer that question, I think part of what the Museum of Science and Industry in Chicago has done is reflect on how to leverage what we do in the inspiration that we have built in our exhibitions as well as our expertise and inquiry based science teaching and thought about how to extend that into our communities and to build partnerships with our communities. So we have designed a set of community initiatives that is intended to build an ecosystem where the ultimate outcome in my mind is that youth and community organizations are getting their first taste of science from the coolest, hippest communicators of science, their brother's best friend who is in one of our other programs. So we start that with the science club approach where we don't have to replicate after-school programs. There are hundreds of community organizations throughout our urban areas that are with kids every day after school. What they need is help in developing sound subject matter, curriculum that is fun and engaging and that the kids can relate to in their organizations after school. So we develop the curriculum, we provide the materials, we train them on the delivery of it, but we do more than that. We do this as an entry to a relationship, not just with the community organizations but also with the children and their families.

So we bring them on buses that we provide back to the museum. On family days, the kids deliver their activities on the floor of the museum to our guests to help develop in them a sense of ownership over our institution and invite their parents in, many of whom have never been to any museum. And we want them to not only—sometimes you have to do more than just invite. You have to take the hand and show them through the door and say, this is your place, we are here to support you. This is the intention of this set of programs. Then we have from that extended service learning, youth development that is all grounded in the science content,

building the public speaking skills and the confidence of the youth from these organizations, and then bridging them into universities.

Last year of the approximately 100 kids that participated in the highest level of this series of programs, the science achievers, 26 of them were seniors in high school. These are regular kids who were not screened from the Chicago Public Schools. Of those kids, every one of them ended up graduating from high school, every one of them ended up getting into a four-year college, and 60 percent of them ended up getting scholarships that we had advocated for them for and supported them in applying for. These kids need access, opportunity and a bridge to engage in science to the full extent. And unless we build these well-structured commitments to our communities, it is not going to be enough. We have to help, invite them in, and hold their hand and have conversations about what is going to work where they are.

Ms. FUDGE. Thank you.

Mr. LIPPINCOTT. I would like to add just a little bit to that. We have actually some very important experiences in what we have been calling a 360-degree because it is exactly what you suggest, that you need to go well outside, in our case, of any sort of television or media approach actually into the community and really understand how that works. Where we have had the most success is where we have had the most funding from the Department of Education. That has to do with early literacy because there are kids coming to school with 800 words where they should have 10,000. And so starting that kind of problem set, how do you help parents in their homes and around their homes, in every part of their lives, use the grocery store as the way to understand language. Show them billboards that invite them to try new kinds of language learning, and you do that through all kinds of pieces of the community as it stands now. Obviously, your best friend's older brother would be a great ambassador for science or for literacy. But we have had to go and we targeted twenty specifically low socioeconomic stratus markets in the United States over the last two years to really experiment. We got the San Diego Chargers to go on the radio and television and endorse and really help kids get invited. We have put billboards, we have done all kinds of alternative activities. We have wrapped the resource and referral vans in southern Illinois in Carbondale with our logos and driven around, giving free DVDs targeted to parents. We have tried things that public television has never done before but really need to be done in order to get inside the community. And by proving that we can make a difference in a few communities, we get other communities to pay attention. And therefore, we play this kind of beginning role. But it really is a 360 approach.

Dr. BELL. Thank you for the question, and I have kind of two—

Chair LIPINSKI. I just wanted to say, we are going to be having a vote probably in 10 minutes or less but we never know if it is more or less. So I just want to keep this going but if we can—I know there are some more questions, so I just want to make you aware of that. I want to hear the rest of the response to the question, but just be aware of that.

Dr. BELL. Very quickly. So there is a line of research within my field of science education that tries to orient to the expertise that

children develop in their life around their interest. So you can think of some of the examples we have been hearing about, these pockets of expertise that kids orient to. And it is something that teachers can orient to as well but often they don't, kind of stopped to do that. So we have a lot of efforts in the curriculum to build on prior knowledge but not to build on prior interests or developing identities of children. And so within the culturally responsive instruction approach, there are efforts to try to take the interests and particular circumstances of everyday life as something to be brought kind of into a science-related learning experience. So that is kind of one response.

Within the Committee report that we did for the NRC, there are a range of partnerships that we have been hearing about between science-rich institutions and communities to try to figure out how to kind of be bringing access to phenomena and engaging experiences to a broader set of populations who tend to be marginalized in school settings just from the research point of view. And those partnerships require active engagement from both sides, between the science-rich institution and the community representation to try to figure out how to broker the experience in relation to the local interest and needs of the communities, the way they talk, the way they engage in particular ways of sense-making to try to negotiate the design of those programs. And when that is done, learning outcomes do represent kind of growth in science knowledge and deeper participation engagement in science-related activity.

Chair LIPINSKI. Dr. Grajal.

Dr. GRAJAL. It is essential to engage, and in our case in Chicago has been with community councils. We actually work with almost 11 community councils, and we have programs in the libraries very similar to one other panelist. It really requires a lot of dedication from the councils and from us. We have to actually pay for the buses for the kids to come to the zoo, we actually have to engage those community councils. We have breakfast with the local churches, with the local minister's association. We really need to engage them to get that kind of involvement. We believe that for example we have a library pass system. Every family can go to any library in the metropolitan area and check out four free passes to the zoo, and those are very, very heavily used, particularly in these communities. Every culture institution has a variation of that, and it really requires that very, very active engagement.

Chair LIPINSKI. Dr. Ferrini-Mundy.

Dr. FERRINI-MUNDY. Yes, just very, very briefly, in addition to these wonderful and exciting ways of engaging the parts of the informal science education community directly with community organizations, youth-serving organizations, I would underscore also the importance of the connections to the formal education community, to leverage the enormous knowledge base within the informal science education community and to find ways to replicate at least pieces of what the school in Cleveland is able to deliver. So lunch with scientists, there are other ways that the informal science education community connects wonderfully with schools. And I think emphasis on playing those out more fully is another way to be sure that we are reaching broadly.

Chair LIPINSKI. I thank Ms. Fudge for her excellent question. I look forward to your contributions to our subcommittee.

Ms. FUDGE. Thank you, Mr. Chair.

Chair LIPINSKI. I would like to recognize Dr. Ehlers for five minutes.

Mr. EHLERS. Thank you, Mr. Chair, and thank you very much. You have thrown out a lot of good ideas, and I am very excited about this and the progress that you have made, in particular the point about educating the teachers, professional development, and that is why I played quite a role in setting of the Math-Science Partnership Program in the Department of Ed and similar program in NSF. And it is crucial that we do this. Personally, when I was still a professor I did a couple of summer institutes trying to develop new science programs in the local schools, and it became clear to me immediately the problem is not the teachers in the sense that they are incompetent. The problem is that we have competent teachers who desperately want to teach science and math well and who never learned it themselves because they have never been taught it properly and have not been taught how to teach properly. So thank for you what you are doing on that.

I just have something sort of off the wall about this type of education, informal education. We have done some work in nanotechnology legislation, and there are some concerns about the social implications of nanotechnology, in particular, the products. And we heard from many groups that the general public has to be better informed on this issue. Well, I could write a long list of things like that, you know, high-powered power lines for distribution of the grid. There is a longstanding belief that somehow living near one of those can cause cancer in your children. Similarly, vaccinations. There are a number of parents, a growing number of parents, who are refusing to have their children vaccinated because there is a belief out there that somehow vaccinations cause autism. And yet, there are other areas where things that should happen but aren't because the public really doesn't understand it. A good example is weight and obesity. I just cringe at some people I see walking down the sidewalk, and I can just lay out for them their life path, what it is going to be in terms of diabetes and other diseases as a result of their weight. I think we need a lot more informal education for adults as well as for children. Obviously PBS could play a major role there. But there are a lot of other things that could happen, too. Involving parents on field trips for example, saying we would like your kids to go on this field trip. It is very, very important, but we would really like to have you come along so that you can discuss it at home afterward or you can even mask it and say we just need you to control this bus full of kids. You know, we need 15 parents to go along with these 20 kids.

So I hope you will put that in your thinking and try to figure out some way to really educate the general public about science as well. I would appreciate any comments you would care to make on that.

Dr. BELL. One thing it makes me think of, in the report there is a chapter on media and its kind of growing prevalence in different forms, and Mr. Lippincott was already kind of giving us a sense of that. In terms of the research base on what people learn

from engaging media, so kind of the broader communication of science, the research is pretty clear around educational television and the science learning that goes on around that in ways that you can measure directly. Although, you know, access to other digital media blogs, virtual spaces, and Wiki's and serious games and all these new emergent technologies, people are engaging with scientific information in radically new ways. And we don't necessarily understand the details of what science they are learning in those moments because we don't have those research literatures to really guide us. So that is kind of the one kind of insight that the Committee developed related to your question which is really a foundational, important question related to science literacy in the broadest sense.

Mr. EHLERS. Now, if we can just get people to watch public television, it might help. Dr. Ferrini-Mundy.

Dr. FERRINI-MUNDY. Yes, thank you for the question and of course, our programs do invite proposals that span the range and are concerned with public understanding at all levels. One quick example, the Nanoscale Informal Science Education Network is a model for how it is possible with partnerships of museums, laboratories, universities, and so on to bring attention to a particular topic for all age ranges, including a number of public forums based on European models for communicating and engaging the public in science. We have several examples, and I agree it is a very important area.

Mr. EHLERS. Yes, I thought I saw one other hand. Yes?

Mr. LIPPINCOTT. I would like to say, we think we are onto something with the media that I tried to show you a little bit about. The fact that kids—not only can we put it in the television programs, but you pointed out what my daughter has said to me which is Dad, if you wanted me to watch it, why did you put it on public television? I guess she doesn't watch public television. But in fact, she is 17 so that is a difficult audience to reach. But our programs do attract broad audiences, and in fact, these online services, just as Dr. Bell has said, we know we are doing something right, but in many cases we don't even know yet what we are doing right. The first week that the service that I showed you last September was made available, we didn't even publicize it and we had a million streams a week, and ever since then we have had a million streams a week. Kids who are 6 to 8 years old are coming to get information. They are exploring it actively in a way that they can't do on television. There is something wonderful happening, but the foundational questions of what is really going on, just as with television, we know they are learning. The question is, what are they learning? And we really need to really understand that as media professionals so that we can do a better job of what you are saying.

Mr. EHLERS. I totally agree, and I think you should tell your daughter that you can't give her an allowance because not enough people watch public television so you don't get paid enough.

Dr. BELL. I will try that.

Mr. EHLERS. Dr. Grajal.

Dr. GRAJAL. The one thing we are finding is that the competition is for leisure time and how people can become active practitioners. One of the things, to consume science information is different than

practicing science. One of the issues that we are facing is not enough time outside, the initiative No Child Left Inside, the issue of not—this is the most sedentary generation and we are finding linkages between overweight, Attention Deficit Disorder, and enough time being outside and exploring nature. The fact that you as a farm boy were doing with your animals and so on is an experience that almost no children have these days.

So we believe that one of the main issues for scientific discoveries by scientific discovery by itself and actually promoting more time exploring science as active actors. It can be in the classroom, but informal settings are unique to provide that experience. So that partnership between being active players of science instead of passive consumers is a really relevant issue here for formal and informal education.

Mr. EHLERS. Ms. Ingram, you get a chance to close it out.

Ms. INGRAM. Just briefly, we recognize that families are critical to whether or not children are going to excel and continue on in their sense of wonder and inspiration in science.

We talk a lot about youth and how to engage because it is a particular problem that exists in advancing science education for our students in K through 8, but families need to be integrated. When we build our exhibitions, we make sure they are accessible for our youth, but they are really designed for the whole family so that they can talk together. It inspires conversation amongst them. It is not a singular experience, it is a shared communal experience. And all the community initiatives we talked about earlier, family days programs need to be embedded in all of that. We truly have to have this be something that the family understands is an opportunity for their youth and an opportunity for them to participate in.

Mr. EHLERS. Thank you very much.

Chair LIPINSKI. Thank you, and we are about seven minutes left in the vote, although we might have a little more time because not many Members have gotten down there. But I just wanted to—one thing I was going to ask, I was just going to throw out there quickly, Dr. Ferrini-Mundy had talked about the Nanoscale Informal Science Education Network Initiative. I am not going to ask you to do it here for lack of time, but I would certainly like to hear more about that and how it was developed and the ongoing work with that because I really am a strong supporter. I really believe, I have said many times that I have drunk the Kool-Aid and believe nanotechnology is the next Industrial Revolution. I truly believe that, and I think it is something that people ought to be educated more about.

But I want to thank all the witnesses for their testimony today. I had mentioned how I had always been excited by science engineering, going to the Museum of Science and Industry. I certainly watched PBS an awful lot. I probably would have been better off if I would have watched more, maybe, and I was a member of the Brookfield Zoo when I was a kid and spent a lot of time there at the zoo and learned a lot there.

So I appreciate very much the importance of informal science education. I think we need to continue to do more. It is good to hear your testimony, but to anything further down the line that

you can recommend to us that we can do here on the federal level to help with this, we certainly do want to hear from you. And I just want to say the record will remain open for additional statements from the Members and for answers to any follow-up questions the Committee may ask of the witnesses, and with that, the witnesses are excused and the hearing is now adjourned.

[Whereupon, at 11:33 a.m., the Subcommittee was adjourned.]

Appendix 1:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Joan Ferrini-Mundy, Director, Division of Research on Learning in Formal and Informal Settings, Directorate for Education and Human Resources, National Science Foundation

Questions submitted by Chair Daniel Lipinski

Q1. In your testimony you discussed the challenge of appropriately assessing and evaluating learning in informal environments. Please elaborate on the standards and benchmarks currently used to evaluate the impact of informal STEM education programs funded by the NSF. What is NSF doing to continue to develop and improve metrics for evaluation?

A1. The NSF has assumed a lead role—drawing on the expertise of its Informal Science Education (ISE) program—in creating a framework of broad categories of potential project impact. In 2008, NSF published an online guidebook, *Framework for Evaluating Impacts of Informal Science Education Projects* (<http://www.informalscience.org/research/show/3643>). The guidebook helps Principal Investigators (PIs) develop appropriate research designs for the evaluation of their projects.

Five impact categories for the assessment of informal education and outreach are discussed in the guidebook (pp. 22–23):

- Awareness, knowledge, or understanding of STEM concepts, processes, or careers
- Engagement or interest in STEM concepts, processes, or careers
- Attitude towards STEM-related topics or capabilities
- Behavior resulting from experience
- Skills based on experience.

These categories represent the types of impacts that are desirable as a result of informal science education activities, and provide a possible framework for standards and benchmarks in the field. The guidebook provides detail about the elements of each of these types of impacts; for example, “engagement or interest” is elaborated for public audiences as “measurable demonstration of assessment of, change in, or exercise of engagement/interest in a particular scientific topic, concept, phenomena, theory, or careers central to the project.” (p. 21). An impact relative to engagement “could be supported by evidence that a project deliverable has evoked short-term interest, or has strengthened prior longer-term interest, in a topic or area of STEM.” (p. 22).

The guidebook also includes recommendations on study designs, assessment strategies, examples, and resources to help potential awardees who may be unfamiliar with evaluation of learning in informal settings. The NSF solicitation for the ISE program points directly to this document. Also, project-level evaluation was a primary focus of the 2009 conference for all PIs supported under the ISE program. As projects reach completion, information about their outcomes is captured in an online project monitoring system for future analysis and synthesis. Some projects provide self-generated quantitative benchmarks for the analysis of their outcomes, though this has not been mandatory because the idiosyncratic nature of impacts and audiences makes for large, inherent variability in expected outcomes.

The NSF-funded National Research Council report, *Learning Science in Informal Environments* (2009) includes a “strands of science learning” framework that proposes the types of science-specific outcomes that might be sought through informal learning environments. According to this framework, learners in informal environments:

1. Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
2. Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
3. Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
4. Reflect on science as a way of knowing; on processes, concepts, and institutions of science, and on their own process of learning about phenomena.
5. Participate in scientific activities and learning practices with others, using scientific language and tools.

6. Think about themselves as science learners and develop an identity as someone who knows about; uses, and sometimes contributes to science. (p. ES-3, Prepublication Copy).

Together, the framework and the strands provide the basis for the development of more specific standards and benchmarks.

The NRC report also includes a chapter on contemporary evaluation issues, approaches, and methods to help move the field forward. Synthesis documents such as this provide us with the information we need in order to advance the field of evaluation of informal science education/outreach.

The Foundation also utilizes online resources to improve evaluation of informal science education activities. For example, the NSF Innovative Technology Experiences for Students and Teachers (ITEST) program sponsors a *Learning Resource Center* web site where ITEST project staff can share information and explore evaluation and assessment practices. It is hoped this type of online community will encourage evaluators to collaborate in the development of standard instruments. Several DRL program solicitations include invitations for proposals to explore assessment methods.

- Q2. *In your testimony, you used the Nanoscale Informal Science Education (NISE) Net initiative as an example of a collaborative effort at the Foundation to broaden participation through informal STEM education. Could you elaborate on the development and ongoing work of NISE Net? Has the NISE Net program been evaluated yet? If so, what are tire findings?*

A2. The Nanoscale Informal Science Education Network (NISE Net) was funded by NSF in FY 2005 through a five-year cooperative agreement with the Museum of Science in Boston, Massachusetts in partnership with the San Francisco-based Exploratorium and the Science Museum of Minnesota, along with many other organizations. Its purpose is to increase public awareness and understanding of, and engagement with, nanoscale science and technology through formation of a national network consisting of science museums linked with nanoresearch centers. Through its growing number of partners, NISE Net has been developing a "catalog" of exhibit units, demonstrations, programs, forums, media, and other resources, as well as a community of practice around their development and use (see www.nisenet.org). For example, *NanoDays* was established last year as a national week-long series of educational activities supported by the NISE Network. This year, during the period March 28 through April 5, more than 200 sites in 48 states, the Commonwealth of Puerto Rico, and the District of Columbia are expected to take part.

Evaluation is integral to NISE Network activities. To guide educational efforts, front-end studies were developed in order to gather initial data on public awareness and understanding. Resources in the "catalog" mentioned above were developed and are being improved through ongoing collaborative, formative evaluation. Since the project is not yet in its final year, summative evaluations have not been completed; however, some initial findings are available. For example, based on a sample of museum visitors exposed to nano-topic programs, exhibits, forums and activities, significantly more of the treatment group than the control group reported an awareness of benefits and risks of nanotechnology [Multi-media Research (Bellport, New York, September 2008) *Summative Evaluation of Awareness of Nanotechnology by the Museum Public*]. Participants in another study who were engaged in a public forum on the potential societal impacts of nanotechnology showed gains in knowledge and awareness of viewpoints other than their own [Multi-media Research (Bellport, New York, September 2008) *Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Health Care*]. This study also demonstrated the multiplier effort of inspiring significant portions of attendees to discuss with others what is nanotechnology and its associated benefits and risks. Additional studies are being carried out, including an evaluation of the effectiveness of the Network itself.

Questions submitted by Representative Vernon J. Ehlers

- Q1. *What are the biggest research questions in need of answers in the field of informal science education?*

A1. Little formal research has been conducted on the relationship between largely voluntary activities and their consequent impacts on STEM learning and continued engagement with science. There are questions and issues in several areas that deserve study and research.

The most pressing questions have to do with the effectiveness of learning in the intersection of formal and informal learning environments:

What is the optimal relationship between institutions of **informal** learning and institutions of **formal** learning, particularly in anticipation of dynamic shifts due to cyber-learning? What are better models of formal-informal collaboration than just good field trips or teacher professional development, and what do we know about their effectiveness? What are the key elements of effective models for coupling the strengths of the formal environments (emphasis on abstractions, symbolic learning, and reflection aided by a knowledgeable guide) with the strengths of the informal learning environments (direct access to phenomena, self-directed learning, affective components)? How can the informal education community's strong understanding of motivation and audience needs be more accessible and useful in the formal education environment?

In addition, questions about outcome measures and the nature of learning in informal settings also need to be addressed:

As noted in the NRC study (*Learning Science in Informal Environments*), learning can comprise multiple strands. How are they woven together in informal settings? For example, how does affective learning (learning that is emotion-based and often driven by curiosity) relate to cognitive understanding or building a science-related identity?

Finally, ongoing work is needed to address learning over the lifespan, the role of technology, and the creation of a theoretical base:

How do people maintain and gain new knowledge of modern and emerging science throughout their lives? Do informal science institutions play a major role in increasing the science knowledge of learners as they age and participate in the activities and requirements of democracy? What other information sources and settings provide lifelong learning opportunities in science, and what features are most effective? How do learners currently transition across settings/media/communities as they learn science throughout their lives? What are the barriers to creating a sustainable, custom-designed trajectory of life-long learning of science?

How can new technologies and participatory models (like Web 2.0, simulations and virtual activities) be harnessed to create a K-to-gray environment where all people play the roles of teachers and learners in their lives? What are the essential design principles of this kind of cyber-enhanced learning infrastructure?

What kinds of intellectual infrastructures will be effective for building knowledge in the field of informal learning? What kind of structure will support accumulation of results of research and evaluation, building on the wisdom of practice, and involving both researchers and practitioners in a common endeavor? How do we effectively utilize cyber-learning technologies so that the field creates, maintains its own truly useful knowledge base?

Q2. How is the existing research made available to the diverse group of informal science practitioners?

A2. The NSF sponsors and supports a major online resource [*InformalScience.org*] to promote and advance the field of informal learning in science and other domains. This site is a place to share knowledge and support a community of learners to inform informal science learning theory, evaluation, standards and practices. The web site was redesigned in September 2008 and, subsequent to the site renovation, log server data is now collected. Based on Google Analytics reports for September 2008–March 2009 (seven months), the site received 16,294 unique visits (avg. 2327/month). It served 84,328 individual page views (avg. 12,046/per month) with an average of 5.18 pages viewed per visit. The site sustained a healthy 00:04:18 average time-on-site and over 70 percent were new site visits with a unique IP address. The most heavily used sections of the site ordered by content type were Member Pages, Research, Projects, Evaluation and Events. As of 30 March 2009, the site has 218 members, a searchable/downloadable repository of 168 evaluation reports (summative, formative, and front-end) that are largely NSF/ISE funded. The research literature database contains 7,628 references relevant to the field of informal learning and science education and the site maintains a calendar of important events, conferences, seminars, and funding deadlines.

The NSF-funded *Center for Advancement of Informal Science Education (CAISE)* provides online tools and resources that connect the informal science education community by stimulating conversation and collaboration across the entire field—including broadcast media, science centers and museums, zoos, and aquariums; botanical gardens and nature centers, digital media and gaming, science journalism, youth, community and after-school programs. CAISE is a partnership among NSF,

the Association of Science-Technology Centers, Oregon State University, the University of Pittsburgh Center for Learning in Out-of-School Environments, and the Visitor Studies Association. Inverness Research Associates serves as evaluator.

NSF-funded reports (i.e., the NRC *Learning Science in Informal Environments* and the *Frameworks for Evaluating informal Science Education Projects*) contribute to the dissemination of new knowledge, as well as scholarly contributions to professional journals such as the *Journal of Museum Education*, *Curator*, *Science Education*, and the *Journal of Research in Science Teaching*. NSF program staff lead and participate in regional and national conferences such as the *American Educational Research Association*, the *Association of Science and Technology Centers*, the *Visitors Studies Association*, *National Science Teachers Association*, and the *National Association of Research in Science Teaching*.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Philip Bell, The Geda and Phil Condit Professor of Science and Math Education, Associate Professor of the Learning Sciences; Director, Institute for Science and Mathematics Education, University of Washington, Seattle; Co-Chair, Committee on Learning Science in Informal Environments, Board on Science Education, National Academy of Sciences, The National Academies

Questions submitted by Representative Vernon J. Ehlers

Q1. What are the reasonable outcomes/goals for informal science learning environments on which evaluations should be based? How can the controversy over defining such outcomes be removed? Are the “six strands” formatted in a user-friendly way for informal science programs to utilize?

A1. The NRC *Learning Science in Informal Environments* report advances the six strands of science learning (introduced in Chapter 2) as the set of comprehensive outcomes that relate to the educational opportunities associated with informal environments and experiences. The summaries and findings of research and evaluation studies included in the report are largely framed in terms of the six strands in a way that we hope allows informal science researchers, evaluators, developers and informal staff to see how the six theoretically-grounded strands relate to their activities. The follow-on NRC volume that is currently in development called *Surrounded by Science* is intended for the practitioner audiences. It is designed to make the six strands—and the findings of the research report, more generally—accessible to a broader audience by documenting in a more practical way how they relate to a set of case studies from informal science education.

One of the main challenges at present in the informal science education field is the development of means for assessing participants’ learning across the range of experiences. Currently, studies that measure similar constructs often include unique measures, scales, or observation protocols. The NRC committee believed more attention should be given to the development of systematic, shared measures and methods for understanding and assessing learning in evaluation and research studies, especially if researchers and evaluators are to attempt assessment of cumulative learning across different episodes and in different settings. Evaluations do need to attend to unique program elements and local contextual features, but the committee was convinced that there were many benefits to be gained from evaluation activities being more explicit about their theoretical foundations. We proposed the six strands as the core dimensions of learning to attend to in those efforts.

It should also be said that the committee was convinced that researchers and evaluators should use assessment methods that do not violate participants’ expectations about learning in informal settings. Learners in informal environments are often motivated by a range of factors, including entertainment, family care, tourism, etc. and so engage in these settings with related expectations (e.g., enjoyment, family bonding, etc.). The educational measures and methods associated with formal academic learning experiences are frequently problematic in this regard. Methods should address the science strands, provide valid evidence across topics and venues, and be designed in ways that allow educators and learners alike to reflect on the learning taking place in these environments. Chapter 3 of the NRC report provides significant detail on state-of-the-art assessment methods related to the six science learning strands.

Q2. Where do you go to find research when developing ISE programs? Have you used NSF-funded or other federal agency-funded research? Are you aware of the 2008 Framework for Evaluating Impacts of Informal Science Education Projects mentioned by Dr. Ferrini-Mundy? And can you provide examples of how federally-sponsored educational research has been applied to existing programs?

A2. The NRC committee found that the literature on learning science in informal environments is vast, but the quality of the research is uneven, at least in part due to limited publication outlets (i.e., dedicated journals and special editions) and a lack of incentives to publish for many researchers and evaluators in non-academic positions. We recommended that researchers, evaluators, and other leaders in informal education should broaden opportunities for publication of peer-reviewed research and evaluation, and provide incentives for investigators in nonacademic positions to publish their work in these outlets.

The committee concluded that further development of common frameworks, standards of evidence, language and values will require new ways to share knowledge and expertise. Several leading thinkers have recognized this need. Journal special

issues, the new Center for Advancement of Informal Science Education (CAISE), and 2008 framework from the National Science Foundation on evaluating the impact of informal science education have initiated and furthered this work, with the goal of contributing to better knowledge integration. We are not aware of a systematic comparison of our NRC *Learning Science in Informal Environments* consensus volume and the 2008 *Framework for Evaluating Impacts of Informal Science Education Projects* (mentioned by Dr. Ferrini-Mundy during the hearing). However, two of the NRC committee members also served on the committee that authored the *Framework* report. They have stated to me that the two reports are intellectually compatible and mutually informative. It seems to me that the NRC report provides a theoretical framing for how to conceptualize and approach evaluation work for different purposes and points to state-of-the-art assessment methods while the *Framework* report provides more extended treatment of the specific measures and methods that could be used for different venues and configurations for informal science activities.

When the NSF funded the NRC *Learning Science in Informal Environments* consensus volume, one of its goals was to compile the high-quality research from informal science education together into one volume so that it could serve as a guiding resource for that quickly developing field. The committee hopes that this research report and the follow-on practitioner volume, *Surrounded by Science*, serve that function to a useful degree. Much of the initial reaction from practitioners to the NRC report has been in this direction; they say that it captures in words much of the wisdom of practice as they understand it. Researchers have reported that the volume will help frame productive discussions within the field that will help guide its development.

Beyond the NRC volume, the NSF has been developing resources that allow the work of the informal science education field to be increasingly cumulative and impactful. The online portals, *InformalScience.org* and the *ExhibitFiles.org*, as well as the more recently funded Center for Advancement of Informal Science Education (CAISE), a coordinating effort for the field, are leading examples in this regard. My personal sense as a learning scientist is that *InformalScience.org* is heavily used by researchers, program and exhibit developers, and evaluators looking to build upon prior projects, much of which is federally funded work. In fact, recently funded projects under NSF's informal science program are required to post project evaluations to *InformalScience.org*. Clearly, the results of prior federal investment are being used in significant ways to inform new developments in the field. Program officers within the NSF's Informal Science Education program would have a detailed sense of these historical lineages in the work.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Andrea J. Ingram, Vice President, Education and Guest Services, Museum of Science and Industry, Chicago

Questions submitted by Representative Ralph M. Hall

Q1. Your teacher professional development workshops sound very successful. I am impressed that you offer these workshops, lesson plans and follow-up materials to these teachers at no cost AND fund their substitute teacher while they attend AND provide a class field trip afterwards. How long have you been doing these? How many teachers have participated? How are they selected? And, how is this program funded?

A1. The Museum's Institute for Quality Science Teaching has offered a year-long teacher professional development workshop series since the 2006–07 school year, making this the third year of the program. Since the program began, 320 teachers have participated in the year-long series. We also work with an additional 700 teachers annually in other workshops ranging from half-day sessions to three-day programs. Our entire scope of professional development programs cost \$565,000 annually and are supported with funds raised by the Museum from individuals, corporations, and foundations.

The workshop series uses an application-based process to select participants. We consider how many years an applicant has taught science, his comfort with teaching science, grades taught (we target 4th through 8th grade), and previous professional development experience in science. Our goal is to enable teachers who most need our help. We aim to work with teachers who are new to the profession as well as those who are more seasoned but are new to teaching science. We consider an applicant's school to help ensure that we work with high-need schools largely in the Chicago Public Schools system but also from high-need suburban and parochial schools. Teachers are required to apply in pairs from schools—to ensure shared resources and continuity within a school—and principals are required to indicate their support of their teachers participating in this program.

Q2. Could you expand a bit on your Community Initiative programs, specifically the Science Minors youth development program and Science Achievers program. I am especially interested to know if you are following these students after they finish high school to see if they continue their education and, if so, choose to pursue a STEM major? If not, I would certainly encourage you to do so, as I believe this would be a real measure of the programs' success. As the program matures, it would be interesting to see if they continue with a career in a STEM field.

A2. The focus of the Science Minors series of programs is on children and teens in the community who are in need of new opportunities. The series includes three levels of engagement which reach over 5,000 students each year. Teens in the Science Minors youth development program attend 10 weeks of science education and training by Museum staff and outside scientists and volunteer to demonstrate science experiments for Museum guests. Throughout their work, Science Minors gain a better understanding of science, a first-hand look at science career opportunities, and public speaking skills. Since the program's debut in 2003, about 400 teens have participated.

In the most engaging level, Science Achievers pursue more rigorous science topics and prepare for college and careers. These teens participate in internships, mentor new classes of Science Minors and even facilitate Science Minors Clubs. They have access to more advanced science experiences and receive additional college and career readiness. This program is based on research that indicates programs that incorporate role models, internships, and college-preparation activities have been shown to increase self-confidence and interest in STEM courses and careers, as well as improving science knowledge and skills and graduation rates. About 100 students participate each year.

We have built a network to provide ongoing support to and communications with our students who have gone on to college. Through social networking sites like Facebook, Museum staff members maintain relationships with grads and invite them back for programs held throughout the year. Last year, 20 of the 24 participants who were seniors received full or partial scholarships. We know at least half of last year's graduates are currently interested in STEM majors.

To fully understand the impact of our programs, we are working with the Chapin Hall Center for Children at the University of Chicago on a project to collect longitu-

dinal data on our students. Chapin Hall has submitted a grant to the National Science Foundation to help fund this effort.

Q3. The House recently reauthorized the National Nanotechnology Initiative. During consideration of this measure in the last Congress, we heard from many groups that the general public needs to be better informed on the pros and cons of the use of nanotechnology. What role do, or could, your organizations play in public awareness campaigns such as this?

A3. The Museum has several initiatives related to this issue. We are connected with NISE-NET and are participating in their NanoDays program—a week-long series of hands-on activities for the public about nanoscience and technology. Museum staff members as well as Northwestern University graduate students are conducting these activities for Museum guests March 28–April 4, 2009. We will continue this program in subsequent years.

The Museum also is in the process of developing a permanent exhibition on nanotechnology that will feature basic information as well as new developments in nanoresearch and applications.

The Museum produced a symposium on “Innovations in Nanotechnology” on Jan. 26, 2008. This event was supported by the American Academy for the Advancement of Science as a sub-award from an NSF grant. The audience was middle- and high school students, their parents, teachers, and Museum of Science and Industry members. The symposium was done in collaboration with the University of Chicago and Northwestern University. We produced a DVD with education demonstrations which will be posted on the Museum’s website.

The Museum also was the location for an episode of PBS’s “Dragonfly TV” science show that featured nanoscience. The episode, “Small is Different,” was filmed in summer 2008 and aired in fall 2008 on PBS stations across the country. In the episode, the young stars, Chicagoans Alettie and Yvonne, learn that nanoparticles are responsible for the colors in some medieval stained glass and see that nanogold makes glass red.

Questions submitted by Representative Vernon J. Ehlers

Q1. Where do you go to find research when developing ISE programs? Have you used NSF-funded or other federal agency-funded research? Are you aware of the 2008 Framework for Evaluating Impacts of Informal Science Education Projects mentioned by Dr. Ferrini-Mundy? And can you provide examples of how federally-sponsored educational research has been applied to existing programs?

A1. When developing ISE programs, we utilize publications and resources from a variety of resources including the National Research Council, U.S. Department of Education, Illinois State Board of Education, American Association for the Advancement of Science (AAAS) Project 2061, National Science Teachers Association (NSTA), *Informalscience.org*, the Association of Science and Technology Centers (ASTC), the Education Development Center (EDC) and the Coalition for Science After School to inform our practices. The 2008 *Framework for Evaluating Impacts of Informal Science Education Projects* has been reviewed and we have started integrating the framework into our planning and development efforts.

Staff with our Center for the Advancement of Science Education use federally funded research to develop programs for teachers and school groups. This includes our year-long professional development workshops series and our hands-on Learning Lab programs for school groups visiting the Museum. We use a range of materials from AAAS Project 2061, including the *Atlas for Science Literacy*, *Benchmarks for Science Literacy*, and *Science for All Americans*, to match program content to what students need to learn as they move from kindergarten through 12th grade. By identifying key ideas, the connections between those ideas, and the ages at which students are most ready to learn them, these tools provide a framework for effective science instruction. For example, in our *Get Energized!* teacher professional development workshop series, we use the *Atlas* to select which energy topic to cover at what time. Our curriculum introduces mechanical energy before moving on to electrical energy, thermal and sound energy, and light energy.

Our efforts have been recognized by AAAS Project 2061, which enlisted our help to develop and host a recent workshop for science museum staff called “Using *Atlas of Science Literacy* in Informal Science Learning Settings.” This workshop was the first time the materials were presented specifically for an informal science institution audience.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Robert M. Lippincott, Senior Vice President for Education, The Public Broadcasting Service (PBS)

Questions submitted by Representative Ralph M. Hall

Q1. Who developed the content for the lesson plans, interactive resources and classroom activities for PBS Teachers, your web service for pre-K–12 educators, and for PBS TeacherLine, your professional development of teachers service? How are these products reviewed and assessed and how are they correlated to state standards, given the broadness of these standards?

A1. PBS Teachers and the associated websites on *PBS.org*, including PBS TeacherLine, have been designed and developed by educators, educational consultants and public media producers working with PBS and local PBS stations. Each has its own advisory group (see attachment).

The kinds of resources sought, and the topics needed for PBS Teachers are specified by the Teacher Advisory Group, a select team of educators who meet monthly by phone and annually in Washington, DC, to review and guide the development of the PBS Teachers sites.

PBS TeacherLine has a national advisory group of educational leaders who oversee the professional development services offered and how these services are correlated to state needs. The group meets via webinar four times per year to review iterative formative product research and to provide guidance on development. The research and evaluation of the services that are most needed and that prove most effective begin with formative research and include longitudinal studies. The evaluation components of our services are critical to maintaining their educational quality and are supported by approximately one-quarter of the total budget.

Each resource submitted is carefully reviewed for accuracy and utility by PBS education content managers. It is then assigned a grade level and tagged with the metadata that will allow it to be more precisely searched by users. The fields of metadata include standard descriptors, including the title and type of resources. We are currently working with teachers to ensure that the resources are aligned to the state standards from each of the 50 states.

PBS will use the services of a nationally recognized vendor competitively selected for quality of service and utility of alignment to encode the state educational standards alignment. Each of these alignments are reviewed by PBS editors, and the materials are commissioned by PBS or contributed by stations and producers. As I mentioned in my testimony, with the launch of our new project we call EDCAR, the Educational Digital Content Asset Repository, these standards-based lesson plans will be available to educators nationwide later this year.

Q2. You testified that less than 20 percent of PBS funding is federal dollars. Approximately what percentage of that federal money is spent on STEM education activities, and which federal entities are the sources of the funds? In what other ways are PBS STEM education activities supported? How closely do you work with industry, and please describe some of those partnerships?

A2. Technically, PBS itself does not receive any federal dollars specifically dedicated to STEM activities. However, PBS' online and on-air content constitutes a wide array of informal learning resources, many of which focus on the areas of science, technology, engineering and mathematics. All sources of funding are invested by PBS for the public media production community, according to the programming interest and educational needs of our member stations and the American public.

The money that we receive from CPB and other federal sources, such as the Department of Education, are invested in content that spans many genres and individual projects such as our interconnection system—the infrastructure that allows PBS to distribute programming to local public television stations—as well as Ready To Learn and TeacherLine.

Our system-wide Science, Technology, Engineering and Mathematics (STEM) Collaborative is creating digital education resources that will ensure that students and educators have access to high-quality, standards-based digital education content—in each of the STEM areas. Within the first stage of the EDCAR launch, we are primed to have a significant pool of digital content focused on topics such as climate science and other STEM-related areas. We understand that television and on-air programs are a just one part of the entire informal learning environment approach. Online broadband access and digital media are dramatically changing the opportu-

nities and challenges the Nation's educators have to improve STEM education. As one educator noted to us when describing her classroom:

"I have found both video and lessons very helpful. The website is also fun for students. I use the videos as focuses in some of the classes and the lessons are pretty awesome. Other than videos students completed an interactive activity called Building Big, which helped them understand many concepts that go into the construction of buildings. They used this knowledge to construct their own earthquake proof building which was later tested."—Sally from Texas, PBS Teacher

Several of our stations are partnering with education organizations to determine the key needs of STEM awareness and how to engage people in the subject. Currently, 74 percent of our stations offer education services that address STEM content. There are plans to create half-hour and hour-long programs; feature STEM related content on existing magazine programs; and run interstitial programming—30-to-60 second programs that air between our longer shows—with enough frequency to impact the viewer.

We continue to work very closely with higher education institutions. Nearly 70 percent of our stations have established partnerships with universities. For example, for the past three years, WFSU in Tallahassee has partnered with Florida State University's laboratory to develop a two-week, hands-on science camp for 80 seventh and eighth grade girls with support from local engineering firms. The camp had tremendous success and has become a signature event for WFSU.

PBS TeacherLine partners with 23 colleges and universities in all 50 states (see attachment) to provide professional development on STEM-related topics. PBS develops its TeacherLine online professional development courses through collaborations with organizations such as the International Society for Technology in Education (ISTE), the National Council of Teachers of Mathematics (NCTM) and the Concord Consortium. PBS Teachers also provides free STEM-based webinars to educators, hosted by educational experts, authors and program producers.

As previously noted, many of our award-winning science and math television programs—NOVA, CYBERCHASE, DRAGONFLYTV and DESIGN SQUAD—are leaders and models, and many of these programs are funded by industry partners, such as the National Science Foundation (NSF):

- NOVA, which receives funding from several organizations, including ExxonMobil, has consistently been the #1 most-used video resource in all U.S. high school classrooms, including all public, cable and network programs, according to studies conducted by Grunwald Associates over the past several years.
- CYBERCHASE—the only math series for children on American TV—reaches five million viewers weekly and receives major funding from NSF, Northrop Grumman and Ernst & Young. The program's companion website, CYBERCHASE Online, has had more than 1.7 billion page views. According to a study conducted by MediaKidz Research & Consulting, students who watched CYBERCHASE found solutions to math problems that were mathematically more sophisticated than students who did not watch the series.
- DRAGONFLYTV—the only all-science television show for elementary and middle-school kids—receives major funding from NSF and Best Buy Children Foundation. Because the show encourages students to pursue careers in science, each episode, along with its website, features a "Real Scientist" segment, which highlights scientists discussing their chosen career. This is noteworthy, considering that "75 percent of Nobel Prize winners in the sciences report that their passion for science was first sparked in an out-of-school environment."
- DESIGN SQUAD is a show in which kids compete in a series of engineering challenges for a chance at a college scholarship. The show receives major funding from the Intel Foundation and additional funding from the National Council of Examiners for Engineering and Surveying, United Engineering Foundation (which comprises ASCE, ASME, AIChE, IEEE, AIME), Noyce Foundation, Northrop Grumman, the IEEE and the Intel Corporation. The show has worked to address a critical need in engineering education and children's television. Since 2007, DESIGN SQUAD and its partners have held 75 trainings for 2,900 engineers and educators and involved 94,805 kids and families in engineering activities.

With additional investment, PBS could do even more to advance STEM education in informal learning environments.

Q3. The House recently reauthorized the National Nanotechnology Initiative. During consideration of this measure in the last Congress, we heard from many groups that the general public needs to be better informed on the pros and cons of the use of nanotechnology. What role does, or could, your organization play in public awareness such as this?

A3. Nanotechnology, as you might recall, was the subject seen during the audio-visual part of my testimony highlighting our website *pbskids.org*, which is aimed at elementary school-aged children. The site allows a user to find video clips that focus on a particular subject—in this case, nanotechnology—send the clip to a friend, play the full episode of the program that contained that clip and even play a game that relates to the video. This video was just one of the many multi-media interactive features of DRAGONFLYTV's website. DRAGONFLYTV is the only all-science show for elementary and middle-school kids on television today.

In November 2008, DRAGONFLYTV focused its entire seventh season on nanotechnology, with the premiere of DRAGONFLYTV as part of a special grant-initiative funded by NSF. The series was among the first television science series to explore this subject area and informed a mass audience about the revolutionary advances taking place in nanoscience and nanotechnology. The series is seen by more than one million people each week and airs on nearly 200 public television stations nationwide. And because 14 million children compose our audience, our award-winning programs such as DRAGONFLYTV and NOVA have educated children, adults and educators on this emerging field.

Nanotechnology is a topic covered by PBS for nearly a decade, currently reaching more than 65 million people weekly, our news and public affair programs, such as NIGHTLY BUSINESS REPORT, NEWSHOUR WITH JIM LEHRER and CHARLIE ROSE, have all highlighted the benefits and issues of concern raised by nanotechnology.

With adequate funding, our vast reach, strong partnerships, innovative producers and high-quality programs leave us well-positioned to successfully address a range of timely and relevant topics from science to literacy. PBS continues to bring a 360-degree approach to address topics that affect all Americans.

Questions submitted by Representative Vernon J. Ehlers

Q1. Could you elaborate on your discussion of the need for national academic standards so that broadcasters, too, have a clearer target upon which to focus?

A1. As I noted in my testimony, PBS is in full agreement with the Council of Chief State School Officers, that it would be more useful and powerful to have a single set of national statements (in the words of a Gates Foundation report) that are “fewer, higher, and clearer” standards shared by all 50 states. This would allow public media and other educational producers to focus more efficiently their creativity and innovation on the shared goals of the Nation's educators. Not incidentally, it would also serve the Nation's educators and students, allowing a stronger, fairer basis for each learner, teacher, school and state to chart and track progress and achievement.

PBS and its production community pride themselves on creativity and effectiveness as educational media producers. We have traditionally been focused on the appeal and the ability of media to attract and to hold the attention of the learning audience. In service to school populations, it is critical that we have aligned ourselves to the tasks teachers need to accomplish. There is no more powerful statement of those tasks than the state standards that every state has articulated. However, the detailed nature of these standards, the sheer number of different—similar, but not the same—statements of goals, benchmarks and milestones reflects the individuality of every state (indeed, Kentucky has three sets of such standards). This makes for a burdensome task, absorbing financial resources well beyond the costs of design and production, of aligning media and teaching resources to such a database and further, for maintaining that alignment as standards are revised.

Q2. Where do you go to find research when developing ISE programs? Have you used NSF-funded or other federal agency-funded research? Are you aware of the 2008 Framework for Evaluating Impacts of Informal Science Education Projects mentioned by Dr. Ferrini-Mundy? And can you provide examples of how federally sponsored educational research has been applied to existing programs?

A2. The producers of PBS informal science television program and online content are well-versed in NSF research and use this knowledge when developing programs. In some cases, we have benefited from having leading experts host our shows for example, Neil deGrasse Tyson, host of NOVA scienceNOW. He is a renowned astro-

physicist who has served on several presidential science-based commissions and often provides his insight and knowledge to the program.

The PBS staff includes former teachers in both our education and programming departments. PBS KIDS content begins with curriculum, and series are created to build knowledge, critical thinking, imagination and curiosity. For example, *SID THE SCIENCE KID*, which debuted in September 2008, is based in national science learning standards, cognitive learning theory and on the preschool science curriculum, *Preschool Pathways to Science*®.

I am aware of the 2008 *Framework for Evaluating Impacts of Informal Science Education Projects*; many of our producers apply it when creating programs. NSF continues to be a major funder of many of our award winning science and math television programs, including *CYBERCHASE*, the only math series for children on American TV, and *DRAGONFLYTV*, the only all-science show for elementary and middle-school kids on television today.

In late 2007, *DRAGONFLYTV* started an interesting experiment in informal science education. This experiment involved the collaboration between *DRAGONFLYTV* and a total of 30 science museums. This collaboration resulted in putting science museums on television for the first time in an ongoing childrens series. Each episode was based on students visits to science museums, carrying out science inquiry and then continuing that inquiry outside the institution, as well as learning about careers in STEM. As required by NSF-affiliated ISE programs, the summative evaluations of this experiment and other NSF-funded programs such as *CYBERCHASE* are all posted on the website *informalscience.org*.

In the case of *DRAGONFLYTV*'s evaluations, students were generally positive about replicating the science investigations they saw modeled on television. As a result, *DRAGONFLYTV* continued its collaboration with science museums for the next season.

We have also received feedback from educators on informal science education such as:

"We enjoy programs that combine math and science skills to promote learning. One of our favorite ways of learning is through TV science and animal programs and Internet sites. The kids love to watch educational programs on TV and then play related online games and search for more related information on what they have learned."—Terri from South Carolina, PBS Teacher

As I mentioned in my testimony, we continue to engage academic and research partners in universities and key government agencies, including NSF, the National Institutes for Health, NASA and NOAA.

Appendix A

PBS TEACHERLINE ADVISORY GROUP

Our Advisory Board includes leaders from educational institutions and professional organizations.

Chris Dede is the Timothy E. Wirth Professor of Learning Technologies at Harvard Graduate School of Education.

Barry Fishman is an Associate Professor of Learning Technologies in the University of Michigan School of Education.

Rob Ramsdell founded FreshPond Education in 1996 and has spent the past 10 years leading the development of professional development programs for K–12 educators.

Margaret Riel is a Senior Researcher at SRI, International, and Visiting Professor at Pepperdine University's online Master in Educational Technology program.

Dr. Mark Schlager is Associate Director of Learning Communities in SRI International's Center for Technology in Learning (<http://ctl.sri.com>).

Claudette Rasmussen is a Senior Professional Development Associate with the Professional Services Group of Learning Point Associates.

JoEllen Killion is the National Staff Development Council's Director of Special Projects.

Raymond M. Rose is the President of Rose & Smith Associates.

PBS TEACHERS ADVISORY GROUP, 2008–2009

Anthony J. Augustin

Now in his 25th year of teaching, Anthony Augustin has spent more than half of his life serving the students of his rural Tennessee school system. During his tenure with the Lawrence County school system, Anthony has taught students in grades 7–12. He holds a Master of Arts in Education degree from the University of North Alabama and is currently working toward an Educational Specialist degree in Educational Leadership. Throughout his career as an educator, Anthony has focused on putting technology into the hands of his students. He has been recognized at local, State, and national levels for his excellence in teaching, and in 2006, he was named a Joseph B. Whitehead Educator of Distinction by the Coca-Cola Scholars Foundation and honored with the Foundation for Rural Education and Development's Rural Teacher of the Year Award. He currently teaches physical, Earth and environmental sciences at Loretto High School in Loretto, Tennessee.

Babs L. Bengtson, Ph.D.

Babs L. Bengtson, Ph.D., is the Director of Educational Services at Penn State Public Broadcasting (PSPB). Bengtson comes to PSPB with 20 years experience in education, winning national awards in instructional design and one national award for her research. She has worked for a variety of companies, including U.S. Airways and Ford Motor Company, where she gained international instructional design experience. Bengtson created and managed her own company, Bridge Builders, for several years before joining Penn State University full time. After joining Penn State in 1998, Bengtson developed professional development programs for K–12 teachers, and has taught several courses for pre-service teachers, helping them learn how to incorporate multimedia in the classroom. Bengtson earned her Ph.D. in Workforce Education/Training and Development from Penn State in 1994 and a Master's of Education in Adult Education, also from Penn State. Her Bachelor of Arts degree in History and English is from Geneva College, a small, liberal arts college in Beaver Falls, PA.

Kevin Clark

Dr. Kevin Clark is an Associate Professor and Instructional Technology Program Coordinator at George Mason University in Virginia. He received his Bachelor's and Master's degree in computer science from North Carolina State University, and a Ph.D. in instructional systems from Pennsylvania State University. Prior to George Mason University, Dr. Clark worked for an educational software company and was a faculty member at San Jose State University. Dr. Clark's corporate experience included positions as a software tester, consultant, content designer, program man-

ager, and founder/director of a non-profit youth program. Dr. Clark's research interests include the application of instructional design principles and learning theories to the design and development of online learning environments. Dr. Clark is also interested in the integration of technology into non-formal learning environments as well as issues related to digital equity. For more information, please visit his homepage.

Traci Feldhousen

Traci Feldhousen is beginning her fourth year home-schooling her two children, currently a third grader and a kindergartener. She graduated from James Madison University in Harrisonburg, Virginia with a double degree in history and Russian language. Over the past few years, she has been a participant in several educational cooperatives and is currently one of the leaders of her local home-school support group.

Jane Ching Fung

Jane Ching Fung has over 24 years of experience in the field of teaching and learning. She is in her 21st year of teaching for the Los Angeles Unified School District and currently teaches full-day kindergarten at the Alexander Science Center School in Exposition Park. She has facilitated professional development in Early Literacy at the school, district, and State level. Jane is an active member of the Center for the Future of Teaching and Learning (www.cftl.org), serves on the board of the National Commission on Teaching and America's Future (www.nctaf.org) and The Larchmont Charter School in Los Angeles (www.larchmontcharter.org). She is a 2002 Milken Educator, National Board Certified, and holds a Master's degree in Curriculum and Instruction (Reading and Language Arts). In 2001, Jane served on Governor Guinn's Education Commission of the States' Early Literacy Council and was a member of the Independent Citizens for California's Children Committee. Her research with Teachers Network Leadership Institute (www.teachersnetwork.org/tnli/index.htm) on new teacher collaboration is included in TNLI's book: *Taking Action with Teacher Research*.

Mary Henton

Since joining National Middle School Association in 1999, Mary Henton has had several positions with the Association, from Director of Professional Development to Director of Integrated Media Initiatives (current). Mary is responsible for providing direction about leveraging technology and media to benefit the Association and its stakeholders. Mary's entire career has been in education. She has been an English teacher, outdoor education teacher, adventure and experiential education trainer and curriculum developer, and consultant in team development and learning. She has a B.A. in English (Gordon College) and an Ed.M. (Harvard University, Graduate School of Education).

Eric Hoefler

Eric Hoefler taught English and creative writing at Woodbridge Senior High School's Center for the Fine and Performing Arts (CFPA) in Woodbridge, Virginia for the past nine years. While there, he helped to design and implement the CFPA program and the Center's four-year creative writing program. In 1999, he created a community-based website for teachers of English and creative writing at the school, which originally connected students through forum discussions but grew to include profiles, blogs, and file sharing. During that time, Eric also helped to develop and teach an online creative writing course as part of the county's Virtual High School initiative. In 2001, Eric became the Technology Liaison for the Northern Virginia Writing Project (NVWP), housed at George Mason University. Through that service, he has helped to integrate online technologies into the Project's work and has led numerous workshops that help teachers to understand how emerging online technologies can further improve the teaching of writing. Currently, Eric is working with a contracting agency for the Children's Bureau to help bring online solutions to the Child Welfare Reform Project, and he continues to work with teachers through his role with NVWP.

Don Jepsen-Minyard

Don Jepsen-Minyard has taught at Crescent Valley High School in Corvallis, Oregon since 1990. Currently, he designs and teaches courses relating to images: Graphic Design, Interactive Design, Photography and a new, team taught English course, Story and Film. Throughout his career, He has maintained an interest both in designing instruction and in personal development. He created a video class for high school students in conjunction with the Journalism department at Oregon

State University and the Northwest Film Center. He completed the Film Center's Media Arts for Teachers program. For two academic years, he collaborated with Bob Madar, winner of the Christine McAuliffe grant, to design and implement project-based curriculum. Two of his students produced "People of the Walamala," a video about the ethnobotany of the Kalapuya Indians, which has been added to many University library collections in the Pacific Northwest. He worked briefly as a consultant for JD Hoyer, formerly the National Director of the Federal School to Work program, to design video-based training materials.

Gregg Legutki

Gregg Legutki is currently a Lead Project Specialist for California Technology Assistance Project (CTAP) in Southern California, covering Riverside, Inyo, Mono, and San Bernardino Counties. Prior to working for CTAP, Gregg was a classroom teacher for over 25 years, mostly in special education. Gregg started out using technology in the classroom with the original Apple for the Teacher Program in the early '80s. He was a technology mentor both at the district and school site level. Gregg has been involved with technology integration for classroom use for well over 20 years. In his current position, Gregg works with schools and districts developing workshops for teachers and site administrators on effective classroom technology integration. He also teaches a teacher prep class for Chapman University on technology integration.

Marnie Lewis

Marnie Lewis received a B.S. in elementary education from Northeastern University in 1994 and in 2002 completed graduate work in instructional technology through George Mason University. She has taught in third, fifth and eighth grade classrooms over the past 10 years. She is currently entering her third year as an Instructional Technology Coordinator for Arlington Public Schools in Virginia. Her role affords her the opportunity to review and evaluate educational sites and software to enhance instruction. She works directly with staff on a daily basis designing and teaching technology infused lessons.

Dan McDowell

Dan McDowell has spent the last eleven years teaching social studies at West Hills. During that time, he has actively been involved in technology integration at the local, State, and national levels, giving numerous workshops and presentations on variety of topics including WebQuests, blogs, wikis, and digital video. Most recently McDowell presented at the National Education Computing Conference in San Diego. In 2002 he was named Classroom Connect's Internet Educator for the Year for the Western United States. In Spring 2006, he completed his MA in Educational Technology at San Diego State University and was awarded the privilege of representing the graduating class as the honor graduate for the department. This fall he was hired by SDSU to teach a graduate level seminar on digital video. At <http://www.ahistoryteacher.com/wordpress>, McDowell blogs about issues related to his day-to-day experiences as a classroom teacher and educational technologist. His online portfolio may be accessed at <http://ahistoryteacher.com/>.

Susim Munshi

Susim Munshi is a Senior Analyst, Technology Planning and Integration, Office of Technology Services-eLearning, Chicago Public Schools. Susim has over 20 years of experience working with students, teachers and administrators. In his current position Susim assists schools with professional development, curriculum design, technology planning, and grant writing. Susim has presented at numerous State and national conferences on cutting edge technology integration solutions in classrooms.

Alicia Narvaez

Alicia Narvaez is Creator/Director of the "Virtual Pre-K & K" program, a national multi-media parent involvement initiative based out of the Chicago Public Schools Office of Early Childhood Education. She is responsible for overall program development and implementation in Chicago and with school districts in Illinois, Texas, California, Colorado and Nevada. In May 2006, the Virtual K program was awarded the Codie Award for "Best Instructional Solution: Students at Home." Prior to her current work in public education, Alicia spent a decade in educational television and media production. Her credits include work for the Discovery Channel, National Geographic Television, CBS News, NOVA, and the BBC.

Sara Reibman

Sara Reibman is a librarian at Biblioteca Las Américas where she works with the staff and students of the Science Academy and the South Texas High School for Health Professions, both magnet schools in the Rio Grande Valley. Sara works on the BLA web site (<http://bla.stisd.net>), the VIVA! Peer Tutor Program (<http://bla.stisd.net/viva.htm>), online services, and photo classes. In 2006, her library won the National School Library Media Program of the Year award from the American Association of School Librarians and she received the Information Technology Pathfinder of the Year award from the same institution. Sara received her B.A. from the University of Maryland in 1975 and her M.L.I.S. from Texas Woman's University in 2000.

Annie Schleicher

Annie Schleicher is an Associate Editor for *NewsHour Extra*, the teen site for the Online NewsHour with Jim Lehrer. Prior to joining the NewsHour she was a high school English teacher and Peace Corps volunteer in Mongolia. She lives in Washington, DC.

Bob Sprankle

Bob Sprankle is a graduate of the University of Southern Maine. He has been a 3/4 Multi-age teacher in Wells, ME for ten years and now serves as the school's Technology Integrator. He was involved with the SEED group in Maine as a Technology Learning Leader and helped train the first wave of teachers using laptops for the seventh and eighth grader MLTI project. Bob was awarded Maine's Technology Teacher of the Year in 2006 from ACTEM. His students have received worldwide recognition for their "Room 208 Podcast," and have appeared in numerous articles, including *The New York Times* and Apple's Education Site. Bob has his own podcast ("Bit by Bit") to help teachers incorporate technology into their classrooms. Both podcasts can be found at <http://www.bobsprankle.com/>

Sandy St. Louis

Sandy St. Louis is educational outreach manager for FRONTLINE where she develops content for the FRONTLINE Teacher Center, an online destination that offers lesson plans and activities to teachers. Prior to joining FRONTLINE, she worked for nearly a decade in documentary film and video distribution to the educational marketplace.

Ceit Zweil

Ceit Zweil is a producer of kids' Web sites at WGBH in Boston. After five years at the helm of the highly-acclaimed ARTHUR web site, she is currently producing the companion site for the new kids engineering series DESIGN SQUAD. She has worked with PBS to pilot new Parents & Teachers editorial guidelines on ARTHUR (and continued efforts to deliver rich supporting online content for grown-ups as producer of the CURIOUS GEORGE Parents & Teachers area. Ceit has served as Project Manager and Content Producer for several other WGBH-produced sites, including ZOOM, TIME WARP TRIO, AMERICAN EXPERIENCE's WAYBACK, and the ARTHUR/Children's Hospital Boston portal for kids. She has a BA in European History from Smith College, and a MA in Theatre Education (with a focus on interdisciplinary education through the arts) from Emerson College. Prior to WGBH, Ceit developed an interdisciplinary arts/science curriculum for a local education company. She is a performer and dance teacher in the Boston area.

APPENDIX B

PBS TEACHERLINE STATION PARTNERSHIPS

Arizona—ASSET-Eight/KAET, Tempe

Arizona Teachers Excellence Program
School Readiness Council, Maricopa County
CCS Presentation Systems (statewide mobile training labs)
Qwest Foundation in Education

Arkansas Educational Television Network, Conway

Arkansas Department of Education
College Credit Partners:

University of Central Arkansas

Colorado—Rocky Mountain PBS, Denver

Colorado Department of Education, Office of Standards and Achievement Support
 Colorado Department of Education, English Language Acquisition Unit
 Centennial BOCES, Learning Services
 Northwest Consortium for Professional Development
 Colorado Association of Science Teachers
 Pueblo City Schools
 Denver Public Schools, ProComp Office
 Public Television Stations:
 KTSC, Pueblo/Colorado Springs
 KRMJ, Grand Junction
 College Credit Partners:
 University of Colorado at Colorado Springs

District of Columbia—WHUT

Howard University, School of Education
 WHUR-FM

Florida—WLRN, Miami

Miami-Dade School District
 Academica, Inc.
 Public Television Station Partners:
 WXEL, West Palm Beach, FL
 WMTJ, San Juan, Puerto Rico
 College Credit Partners:
 Nova Southeastern University

Illinois—WSIU, Carbondale

Southern Illinois University, College of Education

Indiana Public Broadcasting Stations/WFYI, Indianapolis

Indianapolis Public Schools
 Indiana College Network
 Indiana Department of Education
 Indiana Humanities Council's Smart Desktop
 ISTEM
 Indiana Computer Educators
 Public Television & Radio Station Partners:
 WTIU-TV and WFIU radio, Bloomington
 WNIN-TV and WNIN radio, Evansville
 WFWA-TV, Fort Wayne
 WFYI radio, Indianapolis
 WYIN-TV, Merrillville
 WIPB-TV, Muncie
 WNIT-TV, South Bend/Elkhart
 WVUT-TV, Vincennes
 WBAA radio, West Lafayette
 College Credit Partners:
 Marian College

Iowa Public Television, Johnston

College Credit Partners:
Drake University

Louisiana Public Broadcasting, Baton Rouge

Associated Professional Educators of Louisiana
Louisiana Federation of Teachers

Maryland Public Television, Owings Mills

Anne Arundel County Public Schools
St. Mary's County Public Schools
Washington County Public Schools
Baltimore City County Public Schools
Archdiocese of Baltimore Private Schools
Worcester County Department of Professional Development
Allegany County Public School

Massachusetts—WGBY, Springfield

Hampshire Regional School District
Easthampton Public Schools
Massachusetts Department of Education, Office of Instructional Technology
Public Television Station Partners:
Vermont Public Television
Connecticut Public Television
College Credit Partners:
Merrimack College
Westfield State College

Michigan—WKAR, East Lansing

Michigan Department of Education, Office of Early Childhood Education and Family Services
Michigan 4-C Association
Ingham County Health Department, Office for Young Children
Ingham Intermediate School District
Capitol Area Community Services Head Start

Mississippi Public Broadcasting, Jackson

Canton Public School District
Leake County School District
South Delta School District
Yazoo County School District
College Credit Partners:
Mississippi College

Nevada—Vegas PBS

Clark County School District, Licensed Personnel Department

Nevada—KNPB, Reno

Washoe County School District
Elko County School District
Western Nevada Regional Training Program
Northwest Regional Professional Development Program
Northern Nevada Mathematics Council

College Credit Partners:
University of Nevada–Reno, College of Education

New Hampshire Public Television, Durham

New Hampshire Department of Education
New Hampshire Local Education Support Center Network
New Hampshire Regional Professional Development Centers
College Credit Partners:
Plymouth State University

New Jersey Network, Trenton

New Jersey Department of Education

New Mexico—KNME, Albuquerque

New Mexico Public Education Department Rural Education Bureau
New Mexico Division of Higher Education
College Credit Partners:
University of New Mexico

North Dakota—Prairie Public Broadcasting, Fargo

North Central Council for School Television
North Dakota Department of Public Instruction, State Title I Office
Lakes and Prairies Child Care Resource and Referral
Children and Family Services Division of the North Dakota Department of Human Services
College Credit Partners:
North Dakota State University
Minnesota State University, Moorhead

New York—WNED, Buffalo

Science Teachers Association of New York (STANYS)
Reading/Language Arts Association
New York State Mathematics Association
ECLIPSE Science Coordinators
BOCES Model School Coordinators
New York State Teacher Centers
New York State Department of Education
Public Television Station Partners:
WMHT, Albany/Schenectady
WSKG, Binghamton
WLIW, Long Island
WNET, New York
WCFE, Plattsburgh
WXXI, Rochester
WCNY, Syracuse
WPBS, Watertown

Ohio—WVIZ, Cleveland

Tri-County Educational Service Center
Logan County Educational Service Center
Cuyahoga County Educational Service Center
Cuyahoga Special Education Service Center
Greater Cleveland Educational Development Center

Public Television Station Partners:

Think TV, Dayton
 WOUB and ETSEO, Athens
 WCET, Cincinnati
 WGBU, Bowling Green
 WOSU/WPBO, Columbus/Portsmouth
 WGTE, Toledo

College Credit Partners:

Ashland University
 Cleveland State University
 The University of Akron

Pennsylvania—WQLN, Erie

Northwest Tri-County Intermediate Unit
 Northwest Regional Key (supports PA Early Learning Keys to Quality)

Pennsylvania—WITF, Harrisburg

Capital Area Intermediate Unit

South Carolina ETV, Columbia

South Carolina Department of Education
 Public Television Station Partners:
 Georgia Public Broadcasting, Atlanta
 UNC-TV, Research Triangle Park, NC

Tennessee—Nashville Public Television

Tennessee Department of Education, Office of Early Learning
 Metro Nashville Public Schools
 Public Television Station Partner:
 WLJT, West Tennessee State University
 College Credit Partner:
 Tennessee State University

Texas—KLRU, Austin & KLRN, San Antonio

Texas Computer Education Association
 Texas Education Agency, Division of Advanced Academics/Gifted and Talented
 Public Television Station Partners:
 KACV, Amarillo
 KEDT, Corpus Christi
 KERA, Dallas
 KMBH, Harlingen
 KUHT, Houston
 KNOT, Killeen
 KTXT, Lubbock
 KOCV, Odessa
 KWBU, Waco

Virginia—WHRO, Norfolk

Virginia Society for Technology in Education
 Virginia Department of Education
 Public Television Station Partners:
 MHz Networks, Falls Church
 WVPT, Harrisonburg

WCVE, Richmond
WBRA, Roanoke
College Credit Providers:
James Madison University

Wisconsin Educational Communications Board, Madison

College Credit Partners:
Viterbo University

ANSWERS TO POST-HEARING QUESTIONS

Responses by Alejandro Grajal, Senior Vice President for Conservation, Education, and Training, The Chicago Zoological Society

Questions submitted by Representative Vernon J. Ehlers

Q1. Where do you go to find research when developing ISE programs? Have you used NSF-funded or other federal agency funded research? Are you aware of the 2008 Framework for Evaluating Impacts on Informal Science Education Projects mentioned by Dr. Ferrini-Mundy? And can you provide example of how federal sponsored educational research has been applied to existing programs?

A1. To develop informal science education programs, we seek research papers in various publications, both scientific and non-scientific. Some of our top sources are *Science Magazine* (by AAAS) and *Nature Magazine*. *Science Magazine* prints a regular science education feature that provides good and timely reporting on major trends in ISE. Another good source is the *NTSA* magazine (published by the National Science Teacher Association). Although this is a popular-type publication, it brings research results in an accessible way.

We have used some NSF-funded research for Informal Science Education, but I would not consider that our main source of information. We have found that a significant portion on that most of the ISE research is focused on methods to provide scientific content with less emphasis on the process of how the scientific method is acquired and applied by students.

In that regard, the 2008 *Framework for Evaluating Impacts on Informal Science Education Projects* mentioned by Dr. Ferrini-Mundy is an important part of establishing standards for evaluating impacts in ISE, particularly by providing the “Six Strands of Science Learning,” which we believe will become the reference standards for all future ISE evaluation efforts.

In the case of the Chicago Zoological Society, our main source of federal sponsored educational research has been the IMLS (Institute for Museum and Library Services), which has funded some of our programs, including research and evaluation. Our evaluation research is now focused on several important ISE objectives. One of our most recent interests addresses how learners view themselves with respect to science. In particular how minorities and women develop personal images of how they can use science to solve real-life problems.

As we mentioned in our testimony, we find that some research has been hampered by the over-reliance on technology or scientific facts as a metaphor for scientific progress. Those approaches with heavy emphasis on technology or science results tend to overlook that one of the basic components of effective science is the development of personal confidence and strong scientific skills.

Appendix 2:

ADDITIONAL MATERIAL FOR THE RECORD

STATEMENT OF LOANNIS MIAOULIS
PRESIDENT AND DIRECTOR
MUSEUM OF SCIENCE, BOSTON
AND FOUNDING DIRECTOR
NATIONAL CENTER FOR TECHNOLOGICAL LITERACY

On behalf of the Museum of Science, Boston and our National Center for Technological Literacy, I applaud Chairman Lipinski and the Members of the Subcommittee for holding this hearing on the importance of informal science, technology, engineering and mathematics (STEM) education and the opportunity to contribute to it.

ENGINEERING CHANGE: Achieving STEM Literacy and Innovation

With an economy in crisis and a workforce at risk, educating the Nation's future scientists and engineers and advancing technological literacy are more important than ever. And, while there are no easy "fixes," informal education centers can help ensure that future Americans are prepared to make the informed decisions life in a complex technological world requires and to create the products and services that will enable our economy to thrive.

Informal Environments Play a Vital Role in Public and K-12 STEM Education.

According to the January 2009 National Research Council (NRC) report, *Learning Science in Informal Environments: Places, People, and Pursuits*, "tens of millions of Americans, young and old, choose to learn about science in informal ways—by visiting museums and aquariums, attending after-school programs, pursuing personal hobbies, and watching TV documentaries, for example." The report also notes that informal teaming experiences can significantly improve outcomes for individuals from groups historically under-represented in science.

Science centers and museums in particular can spark life-long interest in and understanding of science, engineering, mathematics, and technology. Non-threatening, friendly environments where adults and children can explore without fear of being wrong, museums have resources that many schools do not and offer informal, often interactive, activities that complement the school curriculum. By helping the public investigate the natural world and why and how the human-made world works, science museums help equip young people to live and work in the 21st century, while also increasing the public's ability to make educated decisions. Many of the complex issues that shape our lives require an understanding of basic science, technology, engineering, and math.

The **Museum of Science, Boston** is one of the world's largest science centers and New England's most attended cultural institution. We work to bring science, technology, engineering, and mathematics alive for about 1.5 million visitors a year through our interactive exhibits and programs, serving 100,000 more in traveling and overnight programs. Our landmark, long-range exhibits plan "Science Is an Activity" encourages visitors to practice scientific thinking skills. "Science Is an Activity" has been awarded many National Science Foundation grants and influenced exhibit development at other science centers. The Museum of Science also partners with school districts to bring the excitement of the Museum to the classroom, while providing support and resources for teachers through field trip workshops, pre- and post-visit activities, teacher professional development, outreach, and linking resources to state and national learning standards.

For example, the Museum's **Eye Opener Program** has served 80,000 children from disadvantaged city neighborhoods in the last 40 years. Supported by the Germeshausen Family Foundation and others, 2,500 to 3,000 second graders a year from 45 to 60 Boston public schools explore science and engineering for free and share their experiences with dedicated Museum volunteers. An Eye Opener visit is not just a field trip, but an all-in-one learning experience that begins the week before with a visit by Museum staff. When the children pour out of the buses, they are primed to marvel at a live alligator, climb on a seesaw to learn balance, and more. Meanwhile, as the youngsters tour the Museum, their teachers learn how to use the Museum's resources in their classrooms. The Eye Opener program is also a career and academic learning opportunity for urban high school youth. Duci Goncalves, 28, reported that when she was an Eye Opener teen volunteer, the Museum "opened my eyes and expanded my world. Now, I feel I can do anything." A 2002 graduate of Boston University with a Northeastern University law degree, she works as an attorney with the Youth Advocacy Project in Roxbury.

Each year, the Museum hosts 20,000 youngsters in grades 1–6 and their adult chaperones in a unique **overnight field trip** for a very different kind of learning experience. Since 1985, years before the popular movie, “Night at the Museum,” the Museum of Science has hosted about 435,000 overnights who can sleep beneath a life-sized model of *Tyrannosaurus Rex*, after engaging in hands-on activities focusing on science, technology, engineering and math.

Museums can also be **a valuable community resource**. In addition to on-site visitors, the Museum of Science serves others through outreach programs, K–12 engineering curricula, partnerships, traveling exhibits, and web-based media. Since 1995, the Museum has welcomed under-represented cultural, ethnic, and disabled communities via partnerships with over 3,500 organizations in Greater Boston and surrounding areas. In the last 10 years, over 207,000 under-represented visitors have enjoyed free and/or discounted admission to the Museum and/or participated in Museum or neighborhood-based community events.

When, with the support of the Hearst Endowment, the Museum of Science **traveling program** was able to bring free presentations featuring live animals to 400 public school fifth graders in Holyoke, Massachusetts to spark their interest in biology, Dr. Helen Gibson, Holyoke’s K–8 science academic coordinator, said, “A lot of our children are from homes where poverty is an issue. Having high-quality, hands-on programs from the Museum’s inspiring educators, is wonderful.”

Each year, in over 100 learning environments across the globe, modeled on the Museum’s flagship **Computer Clubhouse**, 25,000 under-served youths worldwide are changing their lives through the creative use of technology and support of adult mentors via the Intel Computer Clubhouse Network. Its “Girls Day” program builds confidence and life skills of girls, using technology to create projects related to their interests.

Connecting Math and Science to Innovation via Technology and Engineering in Formal and Informal Education Settings.

We greatly appreciate that K–12 Science, Technology, Engineering and Mathematics (STEM) education in the United States has received significant attention, in response to international competition, national security, and the need for a well-informed citizenry, however, we are concerned that K–12 technology and engineering education has been largely overlooked. We hope for different results, while following an age-old model of instruction.

Much of our science curricula was established in the nineteenth century, when our society was largely agrarian, and focused on the natural world. There were no cell phones, automobiles, video games, nuclear power plants or space stations. Obviously, our world has dramatically changed but most curricula have not, leaving a huge gap in learning. Teachers and students learn little of the human-made world (i.e., technologies) or of the process in which technologies are created—engineering. While most people spend 95 percent of their time interacting with the technologies of the engineered world, few know that these products, systems and services are created via the engineering design process. Despite the exponential growth and influence of technology in our lives, much of our core curricula remain largely unchanged and only address the human-made world in elective courses or vocational programs. Only in rare instances is engineering discussed or taught.

We need to add technology and engineering as standard content in U.S. public schools and modernize our teaching to reflect our technological world—our widely diverse and technologically rich world. We are not simply referring to computers in the classroom. We advocate and educate for a broader understanding and appreciation of the wide array of technologies, that we often take for granted, like clean water and air technologies, simple and complex transportation technologies, energy technologies, production and distribution technologies, waste disposal technologies, and other engineered solutions that respond to our human needs and sustain our planet.

The key to educating students to thrive in today’s competitive global economy is introducing them to the engineering design skills and concepts that will engage them in applying their math and science knowledge to solve real problems. This is the way to harness the creativity of young minds. This is also the process that fuels innovation of new technologies.

Engaging students in engineering skills—identifying a problem, designing a solution, testing, and improving the design—can offer a platform for applied and integrated learning in math, science, English language arts, and history and social studies. Allowing for failure and hands-on activities, engineering can also open doors for different kinds of learners.

Introducing engineering in K–12 learning opens career opportunities for children of all backgrounds. More than 70 percent of U.S.-born engineers are influenced by

a relative to become an engineer. Children from ethnic groups under-represented in technology and engineering most often do not have the relatives or counselors to guide them to pursue these fields. As minority groups become majority groups, we may see a parallel decrease in U.S.-born engineers. To maintain our country's vitality and security and diversify our workforce, we must expand teacher and student understanding of technology and engineering.

We need to make the "technology" and "engineering" in STEM education as important as the "science" and "math" in all policy-making, funding, K-12 standards and curricula, teacher professional development and certification, and student programs and assessments.

Understanding the importance of scientific and technological literacy and the need for trained scientists and engineers, the Museum of Science launched the **National Center for Technological Literacy® (NCTL®)** in 2004 to enhance knowledge of engineering and technology for people of all ages and to inspire the next generation of engineers and scientists. Through the NCTL, the Museum is working to integrate engineering as a new discipline in schools nationwide via standards revisions, assessment items, research and standards-based K-12 curricula development, pre-service and in-service teacher professional development, and new technology and engineering museum exhibits and programs. The Museum strives to introduce engineering and technology to schools and at least one science center or informal education organization in every state by 2015. The Museum of Science is the only science museum in the country with a comprehensive strategy and infrastructure to foster technological literacy in both science museums and schools nationwide.

An early initiative of the NCTL was to examine and enhance K-12 engineering curricula. The Museum's online *Technology and Engineering Curriculum Review* includes instructional materials in a searchable database (www.mos.org/TEC). The Museum offers educators and students nationwide 2,600 science, technology, math, and engineering curriculum resources and links the Museum's exhibits and programs to state and national standards.

The NCTL is now helping states modify their educational standards and assessments to include engineering, developing standards- and research-based K-12 engineering curricula, and offering educators support and professional development. Involving students in engineering, before stereotyping about math and science discourages them, the our curricula projects are geared to both genders and people of all colors, backgrounds, and cultures. Our **Engineering is Elementary (EiE)** curriculum, for example, integrates engineering and technology with science, language arts, social studies, and mathematics via storybooks and hands-on design activities for 1st-5th graders. Each unit includes an illustrated storybook with a child from a different country and culture who uses the engineering design process to solve a community-based problem. The curriculum has reached over 13,300 teachers and 935,800 students in 50 states and Washington, DC.

This program incorporates research, evaluation, and assessment into its design. On more than 75 percent of questions, students performed significantly better on the post-assessment than on the pre-assessment. In most cases, EKE students performed significantly better than the control. This was true for both genders and all racial/ethnic groups. Students demonstrated, among other things: a better understanding that engineering involves design and teamwork; a better understanding of the engineering design process; and, an increased likelihood of understanding science content related to the unit. Teachers reported gains in their knowledge and understanding of the range of engineering disciplines, what engineers do, and the pervasiveness of engineering.

Engineering is Elementary also shows promising preliminary results in narrowing the achievement gap in a national controlled study of thousands of students who participated in an BE unit and related science instruction, and who participated as the control group in only the related science instruction. In two of the three units studied, the performance gap between low and high socioeconomic students was significantly smaller after participation in an EiE unit.

The Museum of Science's **informal education** efforts involve prototyping museum exhibits and programs that will inspire people to become technologically literate by exploring: 1) what technology is; 2) how it is created and used; and 3) how to make informed decisions about its development, use, and impact. Among the Museum's educational approaches are: 1) a "showcase" presenting new technologies and the latest research, 2) a "creativity workshop" for hands-on problem-solving with technology and invention, and 3) a "forum" focusing on developing critical thinking skills about science and technology issues. The goal is to help the public understand the innovation process—the skills of designing, building, and using technology—and the impact of science and technology. Since 2003, for example, Museum of Science educators have engaged 76,000 young visitors (47 percent boys) and (53 percent

girls) in Design Challenges involving the engineering design cycle and intended to appeal to girls and boys.

Well-Managed Partnerships Create Opportunities.

Science centers, particularly those with a focus on technology and innovation, are well positioned to form **partnerships with the private sector**. It's critical to manage them well. Perhaps most important is setting expectations up front and ensuring that the plan of action will meet both organizations' goals. These partnerships can provide science centers with financial, intellectual, and marketing support. Financial support is the traditional model; firms view this support as part of their marketing, community relations or long-term workforce development, and/or philanthropy. Intellectual support ranges from employee participation in museum programs as presenters, advisors, and conveners of other potential partners to lending or donating artifacts, images, and video.

In addressing STEM advances, the Museum of Science often features the work and knowledge of the world-class science and technology companies, laboratories, hospitals, and universities that surround it. In addition in 1984, the Museum of Science created the **Science Museum Exhibit Collaborative** to develop and share exhibits with other museums across the country. In one case, the Museum collaborated with Lucasfilm Ltd. to create *Star Wars: Where Science Meets Imagination*, a national touring exhibit which has promoted technological literacy since 2005.

For the Museum of Science, intellectual partnerships are critical to supporting a program that reflects current research and advances. Firms offer marketing support, too, as advisors, through co-promotion and communication with employees about the Museum's events. Partnerships can revolve around specific programs or the Museum as a whole. Firms value partnerships. Associating with a science center provide benefits for their employees from free Museum admission and a sense of pride to opportunities for volunteerism, and helping development of well-informed consumers or voters and a science-and-technology-literate workforce. The Museum of Science has developed corporate partnering guidelines to address important issues like content integrity, ethics, and conflict of interest.

The **Beyond the X-Ray exhibit** involved extensive intellectual collaboration between Philips Medical Systems and the Museum, featuring their name and images and engaging their people in Museum activities, including compelling presentations of live 3-D cardiac ultrasound. In this challenging economy, sponsorship from companies also helps reach communities unable to afford a visit as with the Museum's partnering in 2009 with the MathWorks to bring programs on physics, chemistry, astronomy, and animal sciences into the Natick, Massachusetts, public schools.

The Cambridge, Massachusetts, biotechnology company Genzyme has donated hundreds of Museum passes enabling non-profits and schools to visit. A 2006 \$2 million gift to the Museum to create the **Genzyme Biotechnology Education Initiative** supports programs to educate the public about the rapid discoveries in biotechnology and how these advances affect their lives. The programs will include interactive exhibits and educational forums, teacher professional development, presentations for school groups, lectures, Web-based resources, and K-12 science and technology curricula. Genzyme also supports the Museum's model teacher sabbatical program enabling educators to step out of their classrooms and become students at the Museum for five days.

For **partnerships between informal science educators and formal education** institutions, common mission, aligned approaches, funding, and synergistic strengths are key. Successful partnerships have a shared sense of accountability, preferably with written agreements, to deliver on projects and programs. Examples include:

- The Museum's **Building Mathematics** curriculum development projects, created with Tufts University, provides innovative practices for integrating engineering with math to help middle school students develop algebraic thinking.
- To address the national shortage of technology educators, **Closing the Technology & Engineering Teaching Gap**, a new K-12 initiative, is integrating NCTL materials into the fully accredited online technology education programs of Valley City State University (VCSU), North Dakota. The goal is to improve the technological literacy of K-12 teachers and prepare qualified teachers. The NCTL will make its curriculum materials and training available to VCSU via this innovative online teacher certification program.
- The Museum is also working with three Massachusetts community colleges to help educate future elementary teachers via its three-year **Advancing Technological Literacy and Skills** project (ATLAS). It involves the community colleges in developing their understanding of technology and engineer-

ing content and teaching tools. Faculty engage in engineering design challenges, connect technology and engineering concepts with science, mathematics, literacy, and other subjects, learn about technical career options, and modify courses to include technology and engineering. The project will also include outreach to four-year colleges and high schools working with the community colleges to ensure continuity and create a cadre of faculty to introduce this model to colleagues across the state.

- The Museum launched its first school textbook publishing partnership in 2007 with Key Curriculum Press. The standards-based **Engineering the Future® (EtF) curriculum** engages high school students in hands-on design and building challenges reflecting real engineering problems and encourages them to explore what engineering and technology are and how they influence our society. Preliminary studies show that students increase their understanding in all four *Engineering the Future* units. The textbook is narrated by practicing engineers—female and male—from various ethnic and cultural backgrounds.

Research on Informal Learning is Invaluable

Since 2004, the Museum of Science, Boston has conducted over 50 research, evaluation and literature review studies on informal science education, addressing how the Museum engages the public in STEM learning. The Museum has focused on these four areas:

- 1) **Museum-led teacher professional development:** The Museum is exploring ways to enhance the capacity of teachers to engage their students in STEM learning. Early evaluation findings suggest that, in addition to increased knowledge, teachers participating in the programs report feeling “renewed enthusiasm” and “rejuvenation” for teaching and learning about science. This suggests that the ability for informal science learning to enable learners to “experience excitement, interest, and motivation to learn about phenomena in the natural and physical world” may extend not only to children but also to the adults who play a critical role in educating their children. Future research could explore the longitudinal impacts of such programs for teacher interest and motivation for teaching and learning about science, as well as the impact on increased teacher retention.
- 2) **Universal design for museum learning:** Recent Museum of Science studies have found that people with physical, sensory, and learning disabilities can engage in and learn from museum experiences that include multi-sensory interactions and multi-modal interpretations. Some studies also found that people with disabilities report feeling positively about themselves as learners when they can fully participate in and learn from the experience on their own, and report intense negative feelings when a design presents a barrier to learning. Further research could examine the relationship between independent learning and people with disabilities’ identities as science learners.
- 3) **Adult forums:** The Museum of Science has studied the implementation of over 50 events across the country that engage adults in discussing the relationship between science, technology, and society. The Museum has found that adults: attend Forum discussions based on their interest in the topic; highly value the opportunity to engage in these discussions; learn about science and technology content and about the relationship between science, technology and society through these programs. These studies also demonstrate that program participants continue learning about the topic afterwards. Examination of the potential causal relationship between program participation and continued learning is a potential area for further research.
- 4) **Engineering design challenges:** Early studies by the Museum demonstrated that most children complete most steps in the engineering design process when engaged in existing activities, but that children need more help during certain phases of the design cycle than others. Recent research efforts have focused on how exhibit designs and adult involvement can increase children’s engagement in the engineering design process by providing supports and scaffolds that structure the child’s engagement and increase learning through multiple iterations.

Challenges of metrics: The Museum uses many tools cited in the recent NRC report: self-reported learning through surveys and interviews, conversational analysis of videotape data, and observations. The Museum triangulates findings across instruments to reduce reliance on any one instrument. When possible, the Museum

uses existing validated instruments to collect data. The availability of validated instruments is limited, however, especially in the above described areas.

Museums' self-directed, open-ended learning experiences which vary from participant-to-participant are hard to measure, using standardized tests that measure specific constructs, even for our self-contained programs, such as teacher professional development and adult forums. In these programs, adults direct their own learning process, a practice participants report as one of the most valued aspects of these programs. This makes it difficult, however, to study these programs as controlled "treatments." A formalized test would also detract from the self-directed nature of the programs. This is why the Museum relies on self-reported learning to measure learning in adult programs, triangulated with additional instruments such as journals or videotaped conversations.

Another challenge of conducting research and evaluation studies in museums is developing instruments that capture the learning of its diverse visitors, especially in research on universal design. The tools need to be flexible and allow for differences in how individuals receive and convey information. It is important to make sure that regardless of the delivery and collection method, similar constructs or ideas can be elicited from the users.

Major Challenges and Opportunities in Informal Science Learning

Exhibit development: For nearly all science-technology centers, the principal challenges are financial. Drawing support from corporate and individual donors, governmental agencies, and visitors who pay admission, science centers are in jeopardy when the economy is down. With the rising costs of utilities and basic functions, science centers turn to cutting educational programs and deferring maintenance of their facilities in order to stay open. They also turn to program activities that may have a record or expectation of drawing large numbers of visitors, even if those activities do not offer the high level of educational impact to which the NRC report aspires. Science museums can create exhibits that draw large numbers of visitors and address important learning goals, but not without the financial resources. The Museum of Science was fortunate to win an award from the National Science Foundation (NSF) for *Star Wars: Where Science Meets Imagination*, an exhibit that drew over a million and a half visitors in its first eight U.S. venues, with learning experiences focused on engineering design. Future opportunities exist and funding to support imaginative educational exhibit development would be beneficial.

Relevance: Science museums have been so successful at engaging family audiences in science learning experiences that they are under-developed in meeting other community needs, in particular those of adults faced with decisions about how to use science and technology in their lives. That's one reason the Museum launched its National Center for Technological Literacy.

The 5th World Congress of Science Centers recently challenged science museums to pull people together "to create a better future for all through global engagement with issues of local, national, and global relevance." The Museum of Science has also been fortunate to have an NSF grant to establish the **Nanoscale Informal Science Education Network** (www.NISENet.org). The Network is building partnerships between university research centers and science museums to raise public awareness, understanding, and engagement with nanoscale science, engineering, and technology. This is an area of significant current research with future impact upon jobs and STEM careers, as well as possible societal benefits and risks. Over 100 science museums are working with university researchers to address the needs of youth and adults. Funding to support similar network-wide approaches to other topics would further raise the capacity of the public to engage with the larger enterprises of science and engineering that relate directly to their lives. Funding for activities that support public engagement and foster dialogue between experts and lay people also represent an opportunity to bridge important socio-scientific issues.

Two final challenges: First the challenge of inclusion—broadening the reach of informal science education to under-represented audiences, ethnic and racial minorities, people with disabilities, and those in rural communities. Existing programs could be strengthened and disseminated more broadly. The second challenge is professional development. Informal science education is a complex field with only a few opportunities for directly relevant formal education and so in-service professional development is essential.

Recommendations

Key federal agencies such as the Department of Education, National Science Foundation, and NASA can make the "technology" and "engineering" in STEM edu-

cation as important as the “science” and “math” in all policy-making, funding, K–12 standards and curricula, teacher professional development and certification, and student programs and assessments. NASA is uniquely positioned to champion the technology and engineering components of STEM, inspiring children to pursue careers in these areas. NASA can focus more of its grant activity on the technology and engineering curriculum, teacher professional development, and support the development of informal science education programs, such as museum exhibits and television programs. NASA can again become the main driver for STEM education as it was after Sputnik.

As you pursue education and innovation policies and legislation, please also consider the following:

- Remember science museums are excellent providers of teacher professional development and make sure they can participate in such programs;
- Expand and rename the Math/Science Partnerships to STEM Partnerships to include technology and engineering educators in teacher professional development opportunities;
- Support after-school programs that include technology and engineering activities as well as math and science activities;
- Encourage states to adopt technology and engineering standards and assessments;
- Encourage states to include technology and engineering in the definition of “rigorous curricula” for high school graduation; and
- Expand the No Child Left Behind (NCLB) definition and requirement for “technology literacy” to go beyond the use of computers to include the engineering design process.

Thank you for your efforts to highlight the role of informal science education in STEM learning. For more information on our museum programs and services, visit www.mos.org and the work of the NCTL, visit www.nctl.org. If we can provide any additional information, please let me know.

STATEMENT OF THE GIRL SCOUTS OF THE USA

Introduction

Girl Scouts of the USA (GSUSA) is the world's preeminent organization dedicated solely to girls, serving three million girl members in every corner of the United States, Puerto Rico, the Virgin Islands, and ninety-five countries worldwide. Girl Scouts has a long-standing commitment to girls' education and continues to be an authority on their educational needs. Girl Scouts is committed to girls' exploration and pursuit of education and careers in Science, Technology, Engineering and Math (STEM) in order to increase the number of girls pursuing careers in STEM-related fields. We are deeply invested in supporting girls' involvement in STEM education and add a unique voice and proven solutions for Congress to consider while forming policy to assist informal education networks in developing STEM programming.

Girl Scouts applauds the Science and Technology Committee's commitment to ensuring that we have an adequately trained STEM workforce, and submits the following testimony for its review. As the Committee continues to explore the role of informal education in preparing our next generation of engineers, scientists, and mathematicians, please know that Girl Scouts of the USA can provide resources, information, and guidance in shaping public policies that will promote these fields, especially among our nation's girls.

Scope of the Problem

According to the U.S. Bureau of Labor Statistics, jobs requiring science, technology engineering, or math training will increase 24 percent between 2004 and 2014 to 6.3 million. Unfortunately, students' interest in these subjects is decreasing. At the same time, instruction devoted to these subjects has declined due to an increased focus on reading and literacy. Time magazine's report card for No Child Left Behind found that national average class instruction time for math and science in grades 1 through 6 had decreased by 17 and 23 minutes per week, respectively.¹

Girls especially begin to lose interest in STEM early in their education; the percentage of girls who say they would not study math anymore given the choice increases in 4th, 8th, and 12th grade from nine percent to fifteen percent to 50 percent respectively.² While girls consistently match or surpass boys' achievements in science and math in scholastic aptitude tests, achievement tests, and classroom grades, high school girls are less likely than boys to take AP physics or computer science exams.³

This weak academic pipeline, along with other factors, is causing fewer women to pursue careers in STEM fields. According to the National Science Foundation, women represent 46 percent of the total workforce in America, but only 25 percent of the workforce in the fields of science and engineering.⁴ This gender gap holds serious consequences for the future of our country and its girls. A Bayer Corporation Survey of Fortune 1000 STEM executives found that roughly nine-in-ten (89 percent) agree that bringing more women and minorities into STEM fields will help solve U.S. manpower shortages. If our nation is to maintain a competitive advantage in the global economy, we need to ensure that the entire population of young minds is encouraged to explore STEM fields.

History of Girl Scouts and STEM

Girl Scouts is committed to girls' pursuit of education and careers in STEM to achieve parity for girls in STEM-related fields. With over 70 badges and patches in STEM-related activities for Girl Scouts at all levels ages 5–17, girls are encouraged to explore the many ways in which STEM fields relate to their lives. GSUSA brings girls the highest level of STEM opportunities through research-based programming and collaboration with academic and industry leaders. By developing an early interest in STEM fields within a supportive network of caring adults and peers, Girl Scouts are poised to become future world scientists, engineers and scholars.

Girl Scouts STEM programming is provided in a safe, fun, girl-centered environment. Our STEM programming is designed to strategically engage girls in age-appropriate activities that make STEM approachable and fun. Our programs promote gender equality by encouraging girls to explore career and educational opportunities in fields where women are under-represented, while encouraging girls to undertake

¹ *TIME Magazine*. 2007. How to fix No Child Left Behind. *Time Magazine* (May 24, 2007).

² Educational Equity of Girls and Women, National Center for Education Statistics, 2000.

³ The College Board, *Advanced Placement Report to the Nation: 2006* (February 2006).

⁴ National Science Foundation, Division of Science Resources Statistics, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2004*, NSF 04-317 (updated May 2004). Available at <http://www.nsf.gov/statistics/wmpd>

activities that are girl-led, collaborative, and hands-on. Our past and current efforts emphasize a number of different approaches, including public education campaigns, partnerships, mentorship programs, traditional badges and activities, and innovative new programming.

For example, in order to highlight the need to encourage girls' interest in STEM, Girl Scouts partnered with the Ad Council in 2003 to produce a three-year public service announcement campaign. This campaign, aimed at girls, their parents and caregivers, and educators, was launched on television, radio, online, and in print media.

Girl Scouts programming also encourages girls to reach for the stars—literally. Through our partnership with NASA, Girl Scouts can access some of NASA's cutting-edge robotics technology and one-of-a-kind internships. Girl Scouts are able to attend solar science trainings and are given the opportunity to meet NASA scientists themselves.

Our NASA partnership also highlights the importance of role models for girls, whether they are astronauts or engineers. Our *Fair Play* program is a proven, successful initiative run in partnership with the Department of Education and the Intel Corporation that teaches girls about the fields of science, technology, engineering and math through extracurricular experiences. This innovative program features day camp, resident camp, after-school time and university-based implementation models, and includes women who are currently experts in physics, math, design, technology and computer engineering. Hands-on learning and mentoring with adult role models appeals to girls already interested in STEM, as well as those for whom math and science were formerly daunting topics.

Long before these innovative programs existed, however, Girl Scouts offered an array of badges and activities related to nature and other biological sciences. Beyond traditional badges such as "Wildlife," Girl Scout programming includes badges in math, chemistry, computers, and engineering, with badges such as "Build a Better Future," in which girls experiment with engineering design problems while connecting them to their desire to create positive change in their world.

Against this strong history and experience, Girl Scouts is poised to vastly expand our STEM outreach through creation and launch of a new Girl Scout "journey" titled *It's Your Planet, Love It!* A "journey" represents a new way that girls experience Girl Scouting. Rather than pursuing discrete activities and earning individual badges, girls take part in a "journey" along a designated, multi-disciplinary theme. *It's Your Planet, Love It!* uses girls' concern for the environment as a way to bolster their interest in STEM fields. This program focuses on career exploration, hands-on activities, mentoring, and project-based learning in a girl-centric, supportive environment. By increasing STEM literacy among girls, Girl Scouts is preparing a new generation of leaders to tackle the environmental issues of tomorrow.

Policy Recommendations

Girl Scouts strongly supports federal, State and local policies that improve our focus on both the formal and informal STEM education sectors. Informal education organizations especially have a crucial roll to play in the shaping of policy that will positively impact the next generation of the STEM workforce. As the Science and Technology Committee moves forward on this effort, we strongly encourage you to support the expansion of programs that help non-profit organizations—such as Girl Scouts—to promote STEM education and complement formal education. Girl Scouts is looking for opportunities to assist Congress in improving how we as a country promote STEM education in our nation's youth, especially at those points where girls tend to lose interest in STEM: 4th, 8th, and 12th grade. In order to best meet the needs of girls and youth, we recommend the Committee consider and implement policies that encourage:

- **Diverse Learning Environments:** We will not be successful in increasing the number of individuals engaging in STEM fields if we rely solely on the traditional educational setting. Congress must expand efforts to teach STEM fields outside the classroom, in diverse settings. Specifically, spaces must be created for girls where they can explore, investigate, and experiment without fear. Efforts should be made to pilot "girl-only" demonstration projects to engage girls in STEM activities in safe, girl-only environments.
- **Hands-on/Real World Learning:** Limited instruction time, competing priorities, and insufficient resources reduce the availability of hands-on experimentation in the classroom. Our research demonstrates, however, that girls interest in STEM is increased when it is provided in a hands-on, experiential, student-led environment. Furthermore, hands-on learning must be tied to practical, real world applications. To ensure that we are engaging students in

ways that capture their imaginations and interests, Congress should support efforts to expand hands-on, real world, collaborative learning in the informal educational setting.

- **Role Models:** Access to strong and inspiring role models and mentors is a critical way to engage more girls in STEM fields. Congress should create a mentoring program to encourage young women to become involved in STEM education and careers. Such programs should promote the work of non-profit organizations, collaborations with business and industry, partnerships with institutions of higher learning, and other activities that bring together the efforts of the public, private and non-profit sectors. Special emphasis should be placed on programs that serve women, minorities, and people with disabilities.
- **Stigma:** Stigma and stereotypes about STEM fields often keep girls from pursuing these educational opportunities. The desire for social acceptance in school, along with the perception that STEM activities are solitary and uninteresting, discourages young women from pursuing their early interest in STEM. Congress should promote efforts of federal agencies, informal and formal educational partners, and private industry to combat this stigma through public education campaigns. As a leading authority on girls' interests and thinking, Girl Scouts is well-positioned to assist the government in reframing girls' perception of STEM to encourage more girls to engage in STEM fields.
- **Consistent standards:** To ensure the quality of education in the informal setting, Congress should develop nationally consistent learning standards that allow the country's informal sector to provide meaningful resources to teachers around the country and map to national standards.

Conclusions

It is imperative that our nation meet the challenge of educating the next generation of STEM leaders. While formal educational initiatives such as No Child Left Behind have renewed our country's focus on basics such as reading, writing, and math, other STEM-related fields have received less attention in order to accommodate these changes. Although gaps in formal education are increasing, the informal education sector is ideally suited to fill those gaps. Organizations that run after-school programming in conjunction with year-round initiatives, such as Girl Scouts, can help STEM resonate with girls who may have previously found STEM fields uninteresting or irrelevant. Listening to the voices of girls has informed Girl Scouts STEM programming and provides significant and important lessons for Congress' consideration.

Girl Scouts would like to thank the Subcommittee on Research and Science Education for its willingness to investigate the importance of informal STEM education, and looks forward to working with the Committee on these important issues.