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HEARING, *BEYOND THE CLASSROOM: INFORMAL STEM EDUCATION*

TESTIMONY OF

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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.
- 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 underserved 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 students 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 1 to 3 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 our yearlong 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 coursework 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 yearlong 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 daylong 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 underserved 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 careers⁷.

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 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 onsite 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 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.

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

² “Teaching Teachers: Professional Development to Improve Student Achievement,” Research Points, American Education Research Association, Summer 2005 vol. 3 issue 1.

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

⁴ Basu, 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.

⁵ Gibson, 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.

⁶ In the 2007-2008 academic year a total of over 300 teachers participated in IQST programs certified for 1-3 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.

⁷ National Research Council. (2009). *Learning Science in Informal Environments: People, Places, and Pursuits*. Committee on Learning Science in Informal Environments. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, editors. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

⁸ Darke, 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.

⁹ Degenhart, 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.

¹⁰ Building 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.