



The Changing Role of Museums in Advancing Science Education

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Abstract

Museums, science centers, and other informal learning institutions are playing an increasingly important role in promoting science for all learners. The use of non-traditional learning environments and informal learning resources provide unique opportunities to stimulate student interest in science and to deepen their engagement. Museums can reinforce scientific concepts, develop the practices employed by scientists and engineers, and foster an appreciation for the pursuit of science both in school and outside the classroom. Recent findings identify the value of science learning in informal environments and provide evidence that these types of experiences can promote learning in ways that strengthen and enrich school science. This paper outlines a comprehensive model for using the resources of informal learning institutions to strengthen science learning both in and out of the school setting. It explores science education program strategies that target students, teachers, and families at a community-wide level, highlighting key research findings that support this work. The paper shares practical and effective educational approaches that aim to raise interest and participation in science by students across grade levels; influence youth to choose careers in science-related fields; sustain a supportive community climate for science engagement; and facilitate high-quality science teaching and learning in schools.

1. Introduction

Museums, science centers, and other informal learning institutions are playing an increasingly important role in promoting science for all learners. The use of non-traditional learning environments and informal learning resources provide unique opportunities to stimulate student interest in science and to deepen their engagement [1]. Museums can reinforce scientific concepts, develop the practices employed by scientists and engineers [2], [3], and foster an appreciation for the pursuit of science both in school and outside the classroom [4]. Recent findings identify the value of science learning in informal environments and provide evidence that these types of experiences can promote learning in ways that strengthen and enrich school science [5], [6]. Informal learning has been shown to particularly provide opportunities for engaging students from communities historically underrepresented in science [1], [4].

2. The changing museum context

The Museum of Science and Industry has delivered inspiring science experiences to more than 180 million guests since opening its doors in 1933, and continues to act as a science resource for the community. MSI's vision *to inspire and motivate children to achieve their full potential in science, technology, medicine and engineering* serves as the Museum's guiding principle to impact science learning. Each year, 1.4 million visitors experience science at MSI, including 340,000 students on school field trips. In 2008, MSI launched the Center for the Advancement of Science Education (CASE) as the core to its commitment to education. CASE leverages the Museum's unique resources and is dedicated to expanding the number and diversity of future scientists, increasing science literacy among the general public, and improving science teaching and learning in our schools. The Museum's strategy has led to the development of a comprehensive suite of science education programs that place a primary emphasis on engaging underserved youth in science learning, but also building the capacity of their influencers – the communities, families and schools – who support them [7]. Figure 1 depicts the

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relationships between these key audiences and serves as a model for guiding Museum education programs.



Figure 1. MSI Center for the Advancement of Science Education (CASE) Model

The programs are designed to raise student interest and participation in science; influence youth to consider STEM careers; sustain a supportive community climate for science engagement; and facilitate high-quality science teaching and learning in schools.

3. School programs

With the advent of the Next Generation Science Standards (NGSS) [5] in the U.S., schools are implementing new methodologies, standards, and assessments in science education. The NGSS are grounded in three dimensional learning and emphasize engaging students in the practices employed by scientists and engineers, as well as applying crosscutting concepts and understanding core disciplinary ideas. Through student experiences, teacher education, and school leadership development, MSI provides vital support to teachers and schools during this fundamental transition.

3.1 Student experiences

Student experiences provide students and teachers with meaningful learning opportunities that begin in school, center on Museum exploration, and illuminate areas for further science investigation back in the classroom. By narrowing the scope of field trips to specific areas connected to classroom learning, student experiences:

- Increase student content knowledge in science;
- Engage students in the scientific process and build scientific habits of mind;
- Provide insight into real-world applications of science and introduce students to STEM careers.

Learning Labs, the foundation of student experiences, are hands-on science workshops. Labs serve as professional development for teachers as MSI educators model effective instruction that teachers can replicate in their classrooms. Two programs, Live...from the Heart and Mission to Mars, use videoconferencing to provide real-time access to STEM professionals in the field, supporting career connections for students. MSI Learning Labs serve over 20,000 3rd-12th grade students each year.

3.2 Science teacher education

MSI seeks to improve school-based science instruction and increase student achievement in the middle grades by providing sustained and comprehensive science teacher coursework. The Museum's Institute for Quality Science Teaching (IQST) helps teachers deliver effective STEM education through professional development that translates to the classroom. IQST goals include:

- Improving teachers' science content knowledge;
- Increasing teachers' use of hands-on and inquiry-based strategies in the classroom;
- Building teachers' use of external resources.

IQST targets teachers in 4th-8th grade with limited science expertise. Teachers develop a broad science background aligned with classroom curriculum and modeled on the NGSS. Approximately 200 teachers from over 50 schools participate in academic year courses and summer institutes. To date, over 1,000 teachers from nearly 400 schools have participated, impacting over 200,000 students.

A randomized controlled experimental study conducted in partnership with Michigan State University indicated that MSI teacher courses showed statistically significant improvements in program specific content knowledge among participating teachers and their students, as compared to control teachers not participating in the program and their students [6].

3.3 Science leadership initiative

The growth and impact of IQST has positioned MSI to address the significant need to transform science education on a whole-school level through an innovative Science Leadership Initiative. This initiative in its second year, aims to:

- Ensure K-8 students attend a school demonstrating exceptional learning environments for science;
- Engage educators in training and tools to deliver high quality science instruction;
- Support a network of schools in providing exceptional science teaching and learning.

To achieve these objectives, MSI is developing and testing a research-based school support tool to serve as a self-assessment for schools to identify how well they support science teaching and learning. Additional supports for improving schools are being designed along with the identification of resources available from other organizations.

4. Out of school time programs

Social and economic factors play a growing role in student success and today's youth require supports that extend beyond the school day [5]. The MSI model employs the concept of a learning ecosystem [4], placing youth at the center, with resources and supports organized around them. In this approach, schools are extremely important, but are just one of many influencers in a young person's life, including family, peers, and community. MSI's efforts in out of school time complement school-based strategies to maximize the potential of children and youth [7].

4.1 Youth development

MSI's Science Minors/Achievers youth development programs provide opportunities and access for high school age youth from backgrounds traditionally underrepresented in STEM fields. Programs are designed to promote leadership, college/career readiness and service learning, inspiring youth participants to be the next generation of science leaders. MSI's youth development programs:

- Provide diverse youth with access to science learning experiences;
- Open pathways for youth to pursue post-secondary education and consider STEM-related careers;
- Position youth as ambassadors for science learning in the Museum and in the community.

The programs serve 250 youth each year, providing weekly opportunities to participate in STEM

learning, develop communication skills, and explore college and career pathways. Each summer 50 youth are hired as paid science education interns, offering a first work experience while expanding the Museum's reach.

A retrospective study conducted by MSI surveyed 167 program alumni, finding that participation in the program impacted interest in STEM-related careers, particularly among female participants [9]. Currently, MSI is conducting a five-year longitudinal study funded by the (U.S.) National Science Foundation to examine the effect of the program on participants as they move through the college and career pathway.

4.2 Afterschool science

The Museum collaborates with community networks to better meet the needs of local audiences traditionally underrepresented in STEM fields. MSI Science Minors Clubs build the capacity of partner organizations to integrate science into their existing out of school time programs for elementary and middle grade students [10]. The Museum's afterschool science programs are designed to:

- Build a presence for science within communities;
- Expand the capacity of partner organizations to integrate science learning into existing programs;
- Engage children and youth in science learning beyond the traditional school day.

MSI works annually with over 100 partners to offer weekly afterschool science programming for nearly 12,000 children. Through the design of curricula, professional development for afterschool program providers, and implementation support for partner organizations, MSI serves as a model for how museums can support science in non-traditional learning environments.

4.3 Summer learning

MSI partners with the Chicago Public Library to address the educational needs of children during the summer months when school is not in session. Through this partnership, the Museum serves as the lead content partner for the Chicago Summer Learning Challenge, providing a series of literacy, STEM, and art resources for children and families. This model for museum-library partnerships aims to:

- Build the capacity of libraries to integrate STEM learning into existing summer reading programs;
- Establish a presence for the Museum in 80 library branches throughout Chicago;
- Provide children and families with the resources to support continued learning during the summer.

MSI has provided STEM-based professional development for over 700 library staff. Program activities take place in libraries, summer camps, and in the homes of family participants. In the summer of 2016, over 100,000 children from across Chicago participated in the Summer Learning Challenge, establishing it as the largest city summer learning program in the United States.

5. Conclusion

The work of the Museum of Science and Industry represents a step in the evolution of museums and science centers. By focusing on advancing science education, informal learning institutions are playing a significant role in the broader science education arena. Through strategies that extend learning beyond the walls of museums, expand access and opportunities for youth and families, and support improved science teaching in our schools and communities, informal learning institutions can inspire and motivate the next generation.

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