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The STEM Education Movement in Public Libraries

P. B. Dusenbery

The Changing Roles of Public Libraries

This paper examines the changing roles of public libraries in their communities especially the impact that science, technology, engineering, and math (STEM) programs are having on how libraries perceive their evolving mission. Survey results will be presented that show an overwhelming interest by librarians and their libraries in hosting STEM exhibitions and programs. Several successful STEM library programs will illustrate the diversity of approaches that have been implemented including the NSF-funded *STAR Library Education Network* project (STAR_Net).

From climate change to threats to human health and access to clean water, the majority of challenges facing society today – and their solutions – are rooted in STEM (c.f. National Academy of Sciences, 2006; National Academy of Engineering, 2008). Successfully addressing these challenges requires highly competent STEM professionals; students who are engaged with and proficient in STEM content and processes (e.g., critical thinking skills, engineering processes, etc.); and a public that is sufficiently STEM literate to assess the choices before them. In the 21st Century, a basic understanding of STEM is part of being an informed citizen. To meet future STEM workforce demands, we must be able to inspire larger numbers of our ethnically diverse population to pursue a variety of STEM disciplines (National Science Board, 2010).

There is also considerable research about the role that out-of-school (OST) experiences can play in student achievement (Bell et al., 2009; Afterschool Alliance, 2011). Falk and Dierking (2013) observed that "Average Americans spend less than 5 percent of their life in classrooms, and an ever-growing body of evidence demonstrates that most science is learned outside of school." They argue that to have a greater impact on public understanding of STEM, we should explore the role that free-choice (or informal) experiences play in the public understanding of STEM. Bell et al. (2009) concluded that learning experiences across informal environments (such as science centers, zoos, and public libraries) positively influence science learning in school, attitudes toward science, pursuit of science-related occupations, and engagement in lifelong science learning.

Research shows that when families, schools, and communities work together to support learning, then students perform better academically and stay in school longer. In fact, a family's attitude that learning is a positive experience is the single most important predictor of student success (c.f. Henderson and Mapp, 2002; Harackiewicz et al., 2012). Libraries can add community to the equation for academic success. They are places where

communities come together and adults can learn about and support the academic achievements of local students. In a library, parents often participate in hands-on programs and learning opportunities with their children and learn first-hand how to foster their child's growing curiosity about the world.

In 2010, there were 1.6 billion visits to the nearly 17,000 libraries in the U.S. (Institute for Museum and library Services (IMLS), 2013). Libraries serve people of all races, ages, and socio-economic backgrounds. Fully 91% of Americans ages 16 and older say public libraries are important to their communities; and 76% say libraries are important to them and their families (Pew Research Center, 2013). African Americans (60%) and Hispanics (55%) are more likely to say that libraries are "very important" to them and their families compared to whites (41%). They also support segregating library spaces for different services such as learning experiences similar to museum exhibits (Pew Research Center, 2013).

This level of engagement was not always the case. In fact, prior to the 20th Century, very few communities had access to a library. Early in the nineteen hundreds, Andrew Carnegie helped to establish public libraries across the U.S. that were free and accessible to the public. About 2,500 libraries were built between 1883 and 1929. While the Carnegie Foundation paid for construction costs, local communities had to agree to support operational costs. Today, libraries are undergoing a similar transformation; one that is attuned to the needs of the 21st Century (IMLS, 2009).

Considering the ubiquitous role of public libraries in communities, there is surprisingly little research on learning in libraries. In the U.S. National Research Council's consensus report (Bell et al., 2009), there was not a single, significant discussion of the informal science learning that happens in public libraries. While the topic has not gone un-researched, there is certainly no dominant research framework from which to begin.

Informal education environments, such as libraries, are now seen as an untapped STEM educational resource. While research and evaluation in museum settings has grown substantially since the 1970's, the potential of informal learning in libraries is still being explored. Few researchers have investigated how libraries are suited for becoming a place for STEM learning as well as how they fit into an ecosystem of other STEM institutions (Baek, 2013a). There is also a dearth of research exploring how existing informal learning models (c.f. Bell et al., 2009) can help us predict and understand learning outcomes in a library setting.

As part of the STAR_Net project (Dusenbery, 2013) described below, Baek (2013a; 2013b) examined two research questions: 1) How do libraries support the development of STEM learning? and 2) How has the introduction of STEM learning opportunities changed the professional identities of librarians and what barriers and challenges do they face in implementing an effective STEM program within their library?

Baek (2013a) developed a foundational research model for exploring STEM learning in libraries that used the set of informal science learning characteristics identified by Bell et

al. (2009) as well as the concept of a *Third Place* (Oldenburg, 1999; Pastore, 2009). The first place is home. The second place is the workplace (for adults) and schools (for students). Third spaces are the informal meeting places (e.g. pubs, barbershops, cafes) that are anchors of community life that foster creative interactions and community building. The hallmarks of third places include (Oldenburg, 1999): 1) free or inexpensive, 2) accessible, 3) involve regulars, 4) welcoming and comfortable, and 5) encourage conversation. Public libraries can be considered an ideal third place institution because they are free, accessible, welcoming, and have many regulars (especially parents). Baek observed that "By creating an environment that welcomes newcomers to the community, libraries can become an on-ramp to STEM learning".

The public library of today is very different from that of 10 years ago (ALA, 2012). Librarians used to help patrons access card catalogs, indexes, and reference books; now they help patrons choose the right Internet search engine, use interactive websites on specific subjects, learn how to navigate through a myriad of online tools, and are asked more frequently to conduct various types of STEM programs for their patrons. In a follow-up research report, Baek (2013b) examined the impact of STEM programming on librarians using the concept of an *accidental STEM librarian.* This approach can inform the design and planning for professional development of librarians in STEM education. It may be that accidental STEM librarians will be the majority within a library. As a target audience, they will require professional development that addresses their concerns (e.g. STEM anxiety similar to math anxiety) and perceived gaps in competency ("I am not a scientist"). IMLS (2009) has recommended that public libraries support individual development of *21st Century* skills, which include information, communication and technology literacy, critical thinking, and problem solving. In 2014, STEM will be a focus area for IMLS.

As places that offer their services for free, public libraries have become the "public square" by providing a place where members of a community can gather for information, education programming, and policy discussions (IMLS, 2009; ALA, 2012). Just as *21st Century skills* include innovation, creativity, and critical thinking, libraries are developing new ways to engage their patrons in STEM learning (IMLS, 2009). From Portland, Oregon, to Portland, Maine, libraries are hosting Science Saturdays, Robot Races, Maker Spaces (e.g. Good, 2012), hands-on workshops (e.g. Shipp et al., 2008; Smith et al., 2012), and STEM exhibitions (e.g. Korn, 2011; Dusenbery, 2013). Building the capacity of public libraries and library staff to deliver engaging, inspirational, and educational STEM programs has the potential to transform the STEM education landscape across the country. What started some years ago as independent experiments has become a national STEM movement.

Library Interest in STEM Exhibits and Programs

In order to understand the needs and interests of librarians, the National Center for Interactive Learning (NCIL) at Space Science Institute (SSI) and the American Library Association (ALA) surveyed 270 libraries in 2008, distributing an online questionnaire to a national ALA listserv of librarians. There were responses from nearly every state, representing an even sampling of community types: 40% were rural, 36% were suburban,

and 25% were urban. The survey contained 27 questions, including room for two free-write responses, spanning topics from demographics and library mission to exhibit-hosting interests and constraints. The main focus of this survey was on the interest and capacity of libraries to host STEM exhibits that were modeled after exhibits one can find in science museums. Additional surveys have also been conducted that also demonstrate library interest in STEM programs such as a health exhibit survey administered in 2011.

The 2008 survey results demonstrated an overwhelming interest in library-based exhibitions: 73% of libraries have hosted exhibits in the past and 81% plan to do so in the future. Of the libraries that have hosted one or more exhibits, 82% have hosted a history exhibit and 88% have hosted an art exhibit (see figure below). Far fewer have hosted a science (38%) or technology (18%) exhibit; even less hosted engineering or math. The lower numbers of exhibits focusing on STEM disciplines do not express a lack of interest, as libraries responded that they would like to host science (91%) and technology (77%) exhibits in the future. The differential clearly demonstrated a gap between interest and availability. See Figure below.

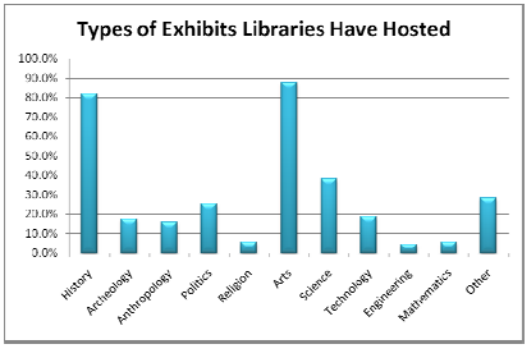

Figure 1: Types of Library Exhibits

With the availability of STEM-oriented exhibits already low, it is the very communities with the greatest need that are most underserved. Rural areas tend to lack access to science centers and museums. Yet, of the libraries that have never hosted an exhibit, more than half (56%) are rural, and 65% claim visitorships of less than 100,000. Of the exhibits that have been hosted, 91% were primarily visual displays and 58% did not contain any interactive or hands-on component whatsoever.

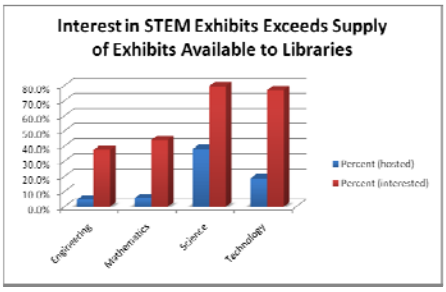

Figure 2: Interest in hosting STEM exhibits

A Sample of STEM Programs in Libraries

Over the last decade several federally-funded projects have brought informal STEM learning experiences into libraries (e.g. Shipp et al., 2008; Smith et al., 2012; Dusenbery, 2013; OMSI's *Libraries of Eastern Oregon* project; Dartmouth's *Pushing the Limits;* and the Franklin Institute's *LEAP Into Science*). However the climate for STEM literacy programs in libraries is changing as more and more libraries across the country begin to offer programs that are fun and educational to their communities such as adding Maker Spaces (Good, 2012) and establishing Learning Labs for teens through MacArthur/IMLS grants. In this section, we review several STEM library programs that were initiated by a variety of organizations that included an exhibit component: 1) Space Science Institute's National

Center for Interactive Learning's (NCIL) *STAR Library Education Network*, 2) Oregon Museum of Science and Industry's *Libraries of Eastern Oregon*, 3) Texas Alliance for Minorities in Engineering's (TAME) *Science Rocks*, and 4) Space Telescope Science Institute's (STScI) *Visions of the Universe*.

STAR Library Education Network (STAR_Net) is a national program led by NCIL. STAR stands for Science-Technology Activities and Resources (www.starnetlibraries.org). Core partners include the American Library Association, Lunar and Planetary Institute, and the National Girls Collaborative Project. Other partners include the Afterschool Alliance, National Academy of Engineering, Engineers Without Borders-USA, IEEE-USA, the National Renewable Energy Lab, American Geophysical Union, Geological Society of America, and many more. *Phase 1* of the STAR_Net project is supported through a grant from the National Science Foundation. The project has developed two interactive traveling exhibits hosted by 19 libraries (*Discover Earth: A Century of Change* and *Discover Tech: Engineers Make a World of Difference*), coupled with a variety of education and outreach programs. This additional programming includes hands-on activities related to the content of the exhibits for different age groups. The project also developed a training program for librarians and an online community (www.community.starnetlibraries.org) of librarians and STEM professionals (currently, over 450 members). To date over 375,000 patrons have visited the exhibits and 15,000 (including 9,000 children) have participated in over 270 programs (ERA, 2013). Over 600 librarians have participated in in-person workshops and online webinars. The STAR_Net program will be featured in a future Informal Learning Review issue.

Figure 3: Discover Tech patron. Courtesy NCIL @ SSI

Libraries of Eastern Oregon. For over ten years, the Oregon Museum of Science and Industry (OMSI) has partnered with Oregon libraries to better provide urban neighborhoods and rural communities with STEM resources, programs, exhibits, and professional development. In addition to providing safe spaces and supporting resources, libraries provide an arm into the community and greatly reduce the time necessary to build trusted community relationships. Through collaborations with the Libraries of Eastern Oregon (LEO) and Multnomah County Libraries (MCL), OMSI is able to focus on providing innovative STEM programs far beyond the limitations of the museum walls. Programs to date have included professional development for librarians, workshops for teachers, connections to researchers and experts through video-conferencing and onsite programming, special events with portable planetarium programs, showcases for small "tabletop exhibitions" and portable spherical display systems, "Maker" programming for teens, science book groups for teens and adults, and forums for community dialogue.

Figure 4: LEO exhibit component. Courtesy OMSI

Science Rocks is a collaboration between TAME, Connecting Texas Libraries Statewide (CTLS, Inc.) and the Texas State Library and Archives Commission. IMLS supports this endeavor through several funding sources. Over the course of two summers this collaborative project has taken TAME's *Trailblazer* van into 67 communities across Texas. Another 23 public libraries are scheduled for visits from the *Trailblazer* in summer of 2014. TAME developed this 40-foot trailer to encourage interest in science and engineering through hands-on activities. The *Trailblazer* features five exciting learning areas showcasing aerodynamics, space, weather, biotechnology, and renewable energy. Volunteers are stationed throughout the trailer to provide explanations and demonstrations. The *Trailblazer* is the only hands-on science and engineering museum-on-wheels in Texas. Most of the towns visited are rural and relatively poor communities that offer little in the way of educational opportunities. There are three main components of the program: the TAME *Trailblazer* visit, staff training on how to present STEM programs in the public library, and developing partnerships within these communities served by the participating library. *Science Rocks* brings the thrill of a hands-on children's museum into these small communities.

Figure 5: Energy exhibit in the Trailblazer van. Courtesy TAME

Visions of the Universe was developed by STScI (Baltimore, Maryland), the Smithsonian Astrophysical Observatory (Cambridge, Massachusetts), and ALA through funding from NASA. The exhibit is part of a multi-year global celebration of astronomy, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo. The goal of the continuing celebration is to create awareness of astronomy's impact on society and culture, and stimulate young people's interest in astronomy and science. Between January, 2009 and July, 2012, this panel exhibition traveled to 64 libraries in 32 states. Exhibit sponsors were especially interested in receiving applications from public libraries in small towns and rural areas that have limited access to NASA resources, as well as from public libraries in larger population centers. Over 525,000 people visited the exhibit and the host libraries conducted about 1,200 public programs (Smith. et al., 2012).

Figure 6: A *Visions* outreach event. Courtesy STScI

Conclusions

Public libraries have been providing lifelong learning for over a century. Although advancements in technology have altered some of the ways libraries deliver services, the fundamental role of libraries remains the same: helping to shape community life and culture by serving as a free educational resource for everyone. While the focus for education reform is on school improvement, there is considerable research that supports the role that out-of-school experiences can play in student achievement and public understanding of STEM disciplines. Libraries provide an untapped resource for engaging underserved youth and their families in fostering an appreciation and deeper understanding of science and technology topics.

A growing number of libraries and librarians understand that they have an important role to play in helping the U.S. to improve its lagging STEM education standings by providing OST experiences for young people and their families, working with schools on joint STEM projects, and exposing children to career possibilities in science and technology. From urban areas to small towns, more and more public libraries want to engage with STEM. The demand in libraries for STEM programs and training is higher than it has ever been and will continue to increase in the years ahead. STEM programs in libraries give audiences of all ages more opportunities to learn, to experiment, and to follow individual interests in science and technology.

With so few libraries hosting STEM exhibits (especially technology and engineering exhibits) and such a large swath of the population visiting them regularly, it's clear that interactive STEM experiences in libraries are an effective way to reach underserved

audiences and increase STEM content knowledge and interest in STEM careers (ERA, 2013). I encourage the Association of Science-Technology Centers and its members to forge strong partnerships between science centers and libraries that can enhance the missions for both institutions. Science centers can help libraries deliver quality STEM programs with resources and expertise they may not have. Libraries can broaden the participation of underrepresented populations in STEM programs at their library and encourage their patrons to visit other informal education institutions such as science centers, museums, aquariums, and zoos. Such partnerships, including ones with research institutes, universities, and community colleges, will help to strengthen and sustain the STEM movement in public libraries that has already begun.

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Author

Paul Dusenbery is the Executive Director of the Space Science Institute (SSI) and the Director of SSI's National Center for Interactive Learning (NCIL). See www.nc4il.org for information about NCIL. He is the PI for the NSF-funded STAR Library Education Network project (DRL-1010844). He may be reached at dusenbery@spacescience.org.