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IN THE PUBLIC INTEREST

Chris Brown, Library Commissioner, Chicago Public Library

COLUMN EDITOR’S NOTE

"In the Public Interest" is an open forum for anyone connected to public library administration to explore the issues affecting our field. In today’s global environment, library administrators must make complex decisions to help institutions achieve their identified mission, vision, and goals. Keeping the bigger picture in mind can be challenging amid all the detailed demands of running a library. This column, then, offers breathing room—space to reflect on a lesson learned, to articulate an insight, to grapple with a question, to clarify a perspective, or to recognize a trend. The ideas expressed here will, I hope, inspire and spark dialogue. Have a topic in mind for a future column? Contact me at cmbrown@chipublib.org.

More than Just the Facts: Contributions of Subject Matter Experts to Out-of-School Time Youth Programs

Robert H. Tai\(^a\), Angela D. Skeeles-Worley\(^b\), Paul Dusenbery\(^c\), Keliann LaConte\(^d\), Jeannine Finton\(^e\), and Claire E. Mitchell\(^f\)

\(^a\)Associate Professor, Department of Curriculum, Instruction, and Special Education, School of Education and Human Development, University of Virginia, Charlottesville, VA, USA; \(^b\)Research Associate, Department of Curriculum, Instruction, and Special Education, School of Education and Human Development, University of Virginia, Charlottesville, VA, USA; \(^c\)Senior Educator Emeritus, National Center for Interactive Learning, Space Science Institute, Boulder, CO, USA; \(^d\)Educational Designer III, University Corporation for Atmospheric Research, Boulder, CO, USA; \(^e\)Sr Program Manager, Society of American Military Engineers, Alexandria, VA, USA; \(^f\)Senior Research Associate, Department of Curriculum, Instruction, and Special Education, School of Education and Human Development, University of Virginia, Charlottesville, VA, USA

ABSTRACT

Background: Out-of-school time (OST) science, technology, engineering, and math (STEM) programming has positive impacts for youth, and the importance of engineering design activities and principles within STEM programming is well-supported by research. Including subject matter experts (SMEs) in these programs enriches the experience of youth participants. Public libraries are widely accessible to the public, and their role in the OST arena is expanding. Library staff can boost the quality of STEM learning experiences by partnering with SMEs.

Purpose: Subject matter experts (SME) contribute more than just their expertise. Between 2018 and 2019, a group of diverse professional engineers and librarians co-facilitated engineering activities at six U.S. libraries serving traditionally underserved populations. This study investigates the alignment in active learning preferences between youth, library staff, and professional engineer volunteers.

Method: The study’s design implemented the Framework for the Observation and Categorization of Instructional Strategies (FOCIS), which identifies seven different types of learning activities: collaborating, competing, performing, discovering, making, teaching, and caretaking. The FOCIS helped researchers evaluate the learning activity preferences of youth participants, engineers, and librarians.

KEYWORDS

Informal learning; subject-matter experts; library-based STEM programming; elementary STEM education; professional engineer; underrepresentation
Results: The analysis showed that the learning activity preferences of youth and engineers were much more closely aligned than those of librarians.

Conclusions: Alignment between youth-program participants and SME program facilitators has the potential to enrich the program experience and foster active engagement.

Introduction

Out-of-school time (OST) science, technology, engineering, and math (STEM) programming has positive impacts for youth (Krishnamurthi et al., 2014), and the importance of engineering design activities and principles within STEM programming is well-supported by research (Brand, 2020; Brophy et al., 2008; Ghalia et al., 2016; NASEM, 2020; Roehrig et al., 2012). Public libraries have offered STEM-based youth programs for over a decade (Dusenbery et al., 2020), even as they face challenges for implementing hands-on activities. Such programs come with logistical concerns involving consumable materials, space, and supervision. Even more challenging is ensuring a quality youth experience. One potential solution is to engage subject matter experts (SMEs) (Jocz et al., 2021) like scientists and engineers. However, these experts should not be expected to pass on their knowledge in a lecture format. Library programs are not focused solely on knowledge attainment, but rather on the engagement of young people. Exemplary programs are fun and hands-on, offering youth the opportunity to discover new ideas, make things, collaborate, and share their knowledge and ideas with others (YALSA, 2016, Shtivelband et al., 2017).

Such programs are typically based on active learning strategies to engage youth more deeply. While science and engineering knowledge and professional experience may enhance and enrich youths’ experiences, it is the manner of engaging in active learning that can play the largest role. Therefore, an important element of library-based youth STEM programming is to consider the most effective ways in which SMEs engage with the youth and program activities (e.g., Johnson et al., 2019, Jocz et al, 2021). How well do the active learning preferences of SMEs align with youth participants? Are engineers’ active learning preferences more closely aligned with youth than librarians? This report explores the issue of SME engagement through the following research questions:

Research Question 1: What types of active learning are emphasized in a library-based youth STEM program?
Research Question 2: What are the active learning preferences of youth participants upon completing a library-based STEM program, and how do youth’s active learning preferences align with the active learning preferences of professional engineers as compared to library staff?

Literature review

The potential of informal STEM learning

Research shows that science learning is a complex, iterative, ongoing process that takes place both within formal academic settings and informal out-of-school time (OST) contexts
OST afterschool, weekend, and summer programs can engage youth and provide content enrichment as well as offer opportunities for mentorship and career development. According to Krishnamurthi et al. (2014), over eight million children and young adults participate in OST programs every year. A growing body of research has shown that afterschool and informal learning can advance STEM learning, as well as inspire greater science engagement and interest. Research has specifically found that, especially when experienced early, informal science learning can instill a greater interest in STEM fields (National Research Council, 2009; Simpkins et al., 2006), inspiring students to make science-related curriculum and career choices (Kong et al., 2014; Maltese & Tai, 2011), and advance their abilities and science-related academic achievement (Dabney et al., 2012; Henriksen et al., 2015).

The potential of informal learning environments has led national organizations such as the U.S. National Research Council (2015) and the Center for Advancement of Informal Science Education (CAISE) to argue that informal learning practices as implemented in “science-designed spaces” like museums, public libraries, aquariums, and zoos play a vital role in engaging youth to learn about the natural world and develop skills needed for science learning (National Research Council, 2009; Bevan et al., 2010). Indeed, the very purpose of a public library is to provide opportunities for self-directed, transformative, and engaging learning (Dusenbery, 2014; Institute of Museum & Library Services, 2009).

**Library STEM programming**

At the moment, research specific to library-based STEM programming—particularly how it can bolster interest, pursuit, and persistence in science-related activities—remains limited. That said, a recent pilot study indicated that public libraries could stimulate situational interest through displays featuring science content (Durik et al., 2021). Meanwhile libraries continued to be widely utilized for co-curricular or informal learning for youth, their families, and communities (Dusenbery, 2014; Dusenbery et al., 2020). In this work, they are increasingly partnering with museums, businesses, schools, and other organizations to offer greater accessibility to hands-on STEM programming (Shtivelband et al., 2019). Such partnerships, along with greater understanding and implementation of instructional technology, have allowed libraries to serve populations of all races, genders, ages, and socioeconomic backgrounds, further elevating public libraries’ mission to provide greater equity and accessibility to knowledge and learning (Cooke, 2016; Subramaniam et al., 2018).

A major advantage of public libraries as a conduit for science learning is their broad geographic reach. In 2017, America’s 17,000 libraries and bookmobiles engaged 118.4 million Americans (a 44% increase since 2008) (Institute of Museum & Library Services, 2020). African American (60%) and Hispanic (55%) respondents are more likely to say that libraries are “very important” to them and their families compared to White respondents (41%) (Zickuhr et al., 2013). Baek (2013) has observed that libraries could become “on-ramps” to STEM learning by creating environments that are welcoming to all. Many public libraries have already created makerspaces that host STEM exhibits and offer hands-on STEM programming (Dusenbery et al., 2020; LaConte & Dusenbery, 2016). Libraries have expanded their circulating collections to include media and
services (Lankes, 2015) like STEM kits for facilitated programs in the library or do-it-yourself programs at home.

Large-scale surveys have shown high levels of community and youth engagement in informal STEM learning provided by local libraries (e.g., Dusenbery, 2014). For example, results from STAR Net’s national library surveys in 2008, 2015, and 2019 captured the importance of STEM programming in public libraries and how interest in offering such programming has changed over time (Dusenbery, 2014; Hakala et al., 2016; Shtivelband et al., 2019). The STAR Library Network (STAR Net) is a national organization focused on STEM learning in libraries. STAR Net’s mission is to help library professionals facilitate STEM learning for their patrons and provide training to use those resources (Dusenbery et al., 2020).

When the Space Science Institute initially surveyed libraries in 2008 (prior to STAR Net), many librarians did not feel comfortable conducting STEM programming, didn’t know that STEM exhibit opportunities were available to them, as they were far more comfortable with history and literature subjects, and did not feel like they had received any instruction on how to implement a hands-on STEM program (Dusenbery, 2014).

The landscape had changed dramatically by 2015. That year, a survey of more than 500 library and STEM professionals across the country found that many libraries were already integrating STEM into their programming and were eager to receive training to facilitate a greater range of informal science activities (Hakala et al., 2016). When asked to rank a list of items that would be most helpful to increase the amount of STEM programming opportunities in their community, library professionals highlighted the need for “how-to” procedures for conducting hands-on STEM activities, crafts, and demonstrations; sample program ideas; and sources for ready-made programming materials and kits.

The latest STAR Net library survey, conducted in 2018 and reported by Shtivelband et al. (2019), found that of the 717 responding libraries, 49% of which were in rural/small communities, 75% offer STEM programming “more than once per month” or “monthly.” Most libraries surveyed (91%) were extremely interested or interested in offering more STEM programming, and 69% felt “ready” to offer STEM programs and activities to their patrons. In just a few years, libraries around the country have significantly shifted—and continue shifting—their practice toward STEM.

**Methods**

**Ready-set-create programs**

Between 2018 and 2019, Project BUILD (Building Using an Interactive Learning Design) ran an experimental program, called Ready-Set-Create (RSC), for youth in grades 2 through 5 and their families along with librarians and professional engineers in an informal learning environment. The program offered age-appropriate, technology-rich STEM learning experiences fundamental to the engineering design process (Figure 1). Project BUILD was funded by the National Science Foundation (NSF) and led by the Space Science Institute’s (SSI) National Center for Interactive Learning (NCIL), in partnership with the University of Virginia (UVA), and the American Society for Civil Engineers (ASCE). An external evaluation of the program was conducted by Education Development Center, Inc. (EDC). Project BUILD is part of NCIL’s STAR Net program.
Ready-Set-Create (RSC), was divided into four areas: Span-tastic Bridges, Clean Up Our World, Designed to Survive, and Power from Nature. Program developers created an extensive activity guide for each area. The RSC program spanned four monthly sessions and was implemented in six public libraries and one afterschool program. The six public libraries, three rural and three urban, were in Alaska, Colorado, Florida, Ohio, Pennsylvania, and West Virginia. Volunteer engineers from ASCE facilitated the sessions. Each lasted between 1.5 and 2.0 hours, allowing youth plenty of time to explore and engage with library staff, volunteer engineers, caregivers, and each other.

The goal of Project BUILD through the RSC program was to increase youths’ understanding of the engineering design process (Figure 1) and motivation to pursue STEM-related educational and career pathways, especially youths from rural and/or geographically isolated areas and populations traditionally underrepresented in STEM. Evaluation of the results provided valuable insights on the importance of the engineer/librarian partnerships (Jocz et al., 2021; Jocz & Greller, 2020). The concept of the program was for host library staff and engineers from ASCE to co-plan and co-facilitate. Head librarians and engineers met in-person in 2018 at a Project BUILD workshop held in Denver, CO. The in-person training session enabled the librarians and engineers to form a relationship and common vision fundamental to a successful partnership. On a more practical level, they also worked out some logistical details (Jocz et al., 2021). For example, library staff learned that engineers may not be available during the day so educational events had to be scheduled accordingly.

Based on the program evaluation (Jocz & Greller, 2020), all librarians and most (80%) engineers agreed or strongly agreed that the collaboration was beneficial. Having engineers with content knowledge present at the programs helped librarians feel more comfortable facilitating engineering-related activities. Librarians noted that the engineers had great suggestions for integrating engineering concepts into the program, e.g., giving local examples, describing how the activities connect to the work of engineers, and also provided tips on making the activity work better. The engineers benefited from library staffs’ expertise working with young children. Prior to RSC, only half of engineers and
one-third of library staff agreed or strongly agreed that they felt confident carrying out program facilitation. Their confidence increased to 89 and 78% respectively after participating RSC.

**Analysis and instrument**

Researchers evaluated the four RSC activity guides through the lens of the Framework for the Observation and Categorization of Instructional Strategies (FOCIS) for active learning (Ryoo et al., 2020; Tai et al., 2021). The FOCIS framework posits that there are seven different types of active learning in STEM-based youth programs (Figure 2): making, discovering, collaborating, competing, performing, caretaking, and teaching.

**Research question 1**

A team of five reviewers determined which of the seven learning types were used in each of the four RSC sessions by analyzing the curricula. The results are shown in Table 1 of the Results section.

**Research question 2**

The youth in RSC were asked to complete a post-participation survey asking them to rate their preferences among the seven different types of active learning. The survey is shown in Figure 3. Engineers and librarians filled out a similar survey, which had 28 questions instead of 14. Subsequent analysis only used the 14 questions that matched the youth survey.

The analysis relied on a regression tree approach: testing for homogeneity among groups, then keeping similar groups together while splitting off groups that are different. This type analysis is growing in popularity among many fields due to flexibility.
regarding data structure, ease of interpretation, and accuracy (Grubinger et al., 2014; Srour & Karkoulian, 2022; Venables & Ripley, 2013). The Decision tree analysis was conducted in SPSS® version 26 using the CRT (Classification and Regression Trees) option.

### Sample

#### Youth

Of the 381 youth participants who filled out surveys, 42% identified as girls, 48% identified as boys, 2% identified as transgender or gender-nonconforming, and 9% opted not to report their gender (Table 1). Half of the participants did not report their grade level, but of the responses received, most were in elementary school (1st to 5th grade: 75%), with smaller percentages in Pre-K and K (4%), middle school (6th to 8th grade: 17%), high school (9th grade: <1%), or other grades (3%; Table 2). About a quarter of participants opted not to report race/ethnicity, but of the responses received, the greatest portion of participants identified as White (35%), followed closely by participants identifying as Black (24%) or more than one race/ethnicity (17%). Other participants

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**Figure 3.** Active learning preferences survey questions answered by youth participating in the Ready-Set-Create library-based STEM programs.
identified as Asian (11%), Hispanic/Latinx (7%), American Indian/Native American (4%), Pacific Islander (<1%), Middle Eastern (<1%), or another race/ethnicity (1%: Table 3).

**Engineers**

The engineers who participated in RSC were all members of the American Society of Civil Engineers (ASCE). Some were recruited at leadership training conferences in 2019. Program organizers also contacted ASCE Outreach Champions, a group of ASCE engineers who are interested in pre-college outreach. Their post-participation survey generated 104 responses, with nearly equal representation of men (51%) and women (48%), and 1% electing not to report their gender (Table 1). Most were 24–39 years old (47%). Otherwise, 25% were 18–23 years old, 18% 40–54 years old, 8% 55 years or older, and 2% elected not to provide their age (Table 2). Most participating engineers (70%) identified as White, 11% as Latinx, 10% as Asian, 7% as more than one race/ethnicity, 4% as Black, 1% as American Indian/Native American, 1% as Pacific Islander, and 1% opted not to report their racial/ethnic identity (Table 3).

Note: To have the adequate sample size for an analysis of this type, both ASCE engineers who co-facilitated the RSC programs and ASCE engineers who were not engaged with the RSC program were surveyed.
**Librarians**

Library professionals were recruited for the study survey through the STAR Net newsletter in November and December of 2021. A total of 56 librarians completed the survey, 90% of whom identified as women, 3% who identified as men, and 7% who opted not to report their gender (Table 1). Most librarians were in the 40–54 (39%) and 55–73 (32%) age ranges, with another 17% aged 24–39 years, 5% over 74 years old, and 7% who did not report their age (Table 2). Most of the librarians identified as White (80%), with 7% identifying as more than one race/ethnicity, 4% as American Indian/Native American, 4% as Black, 2% Hispanic/Latinx, 2% Asian, and 2% Middle Eastern/North African (Table 3).

Like the engineers, the survey included librarians who did not co-facilitate the RSC program.

**Results and discussion**

We begin our discussion of the findings by addressing Research Question 1:

*What types of active learning are emphasized in the library-based youth STEM program?*

The curriculum analysis of Ready-Set-Create (RSC), shown in Table 4, revealed four types of active learning: making, discovering, collaborating, and performing. Links to detailed session activities can be found in the Appendix.

Next, we address Research Question 2:

*What are the active learning preferences of youth participants upon completing a library-based STEM program, and how do youth’s active learning preferences align with the active learning preferences of professional engineers as compared to library staff?*

The average active learning preference scores for youth, engineers, and librarians are shown in Table 5, along with the respective standard deviations. Youth had the strongest positive preference for making activities, although discovering and collaborating also received high marks. Performing received a weak preference score of 3.52, indicating that the youth were neutral or negative toward performing types of active learning.

A second look at Table 5 reveals that the youth preference scores were closely aligned with engineers’ preference scores.

Researchers wanted a more in-depth perspective on the data, so they used CRT (Classification and Regression Trees) analysis (Figure 3). With respect to the preference for making, librarians split off first, retaining youth and engineers as a group (Figure 3(a)). A second-tier analysis split youth from engineers. The result for the discovering preference scores follows a similar pattern (Figure 3(b)). This outcome indicates that for the making and discovering preferences, the youth and engineer groups are significantly more homogeneous or “aligned” than the librarians. For collaborating and performing learning preferences, engineers and librarians are more closely aligned. (Figures 3(c,d) and 4).
Table 4. Curriculum evaluation of the four *Ready Set Create* sessions shows concentration in four types of active learning.

<table>
<thead>
<tr>
<th>Session</th>
<th>Description</th>
<th>Making</th>
<th>Discovering</th>
<th>Collaborating</th>
<th>Competing</th>
<th>Performing</th>
<th>Caretaking</th>
<th>Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spantastic Bridges: from here to There</td>
<td>Youth explore successful bridge-building and use a variety of materials to build and test their own designs.</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean Up Our World</td>
<td>Youth explore sources of pollution and test different strategies for cleaning water.</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Power from nature</td>
<td>Youth use “green” energy to power creative constructs, such as circuits, “puff mobiles,” &amp; turbines.</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designed to survive: engineering for disasters</td>
<td>Youth create and test structures to withstand disasters such as earthquakes and storms.</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. Active learning preference scores for youth, engineers, and librarians.

<table>
<thead>
<tr>
<th>Active learning types</th>
<th>Youth mean (SD)</th>
<th>Engineers mean (SD)</th>
<th>Librarians mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making</td>
<td>4.64 (0.78)</td>
<td>4.27 (0.78)</td>
<td>3.71 (1.00)</td>
</tr>
<tr>
<td>Discovering</td>
<td>4.29 (0.92)</td>
<td>4.41 (0.66)</td>
<td>3.75 (0.99)</td>
</tr>
<tr>
<td>Collaborating</td>
<td>4.22 (0.98)</td>
<td>4.00 (0.82)</td>
<td>3.69 (1.02)</td>
</tr>
<tr>
<td>Performing</td>
<td>3.52 (1.28)</td>
<td>3.70 (0.89)</td>
<td>3.65 (0.99)</td>
</tr>
</tbody>
</table>

Figure 4. Results of the SPSS® v.26 decision tree analysis.
Conclusions

Public libraries are essential for increasing STEM literacy in the U.S. (Dusenbery, 2014). As library-based STEM youth programs proliferate (Dusenbery et al., 2020; LaConte & Dusenbery, 2016), it is imperative to evaluate and improve the quality of these experiences. Partnering with subject matter experts (SMEs) is one way to strengthen programs, especially if their involvement goes beyond their knowledge basis and to engage in hands-on, active learning and mentorship.

In the case of the Ready-Set-Create (RSC) library-based youth program, professional civil engineers served as SMEs. Follow-up surveys revealed that the active learning preferences of SMEs were more closely aligned than library staff. Youth and engineers shared an interest in making and discovering, rather than collaborating and performing. Designing programs around the making and discovering learning styles has greater potential for sincere personal engagement and, therefore, creates a channel for genuine connection between youth and SMEs. After all, many engineers choose their profession because of their desire to make and discover new things. Such enthusiasm can tap into the natural curiosity and imagination of young people. And, because public libraries are open in the evenings and/or on weekends, it is possible for SMEs to volunteer for programs outside their working hours.

The fact that librarian preferences differed significantly from those of engineers and youth should not come as a surprise. Not all library professionals feel comfortable or equipped to offer STEM learning experiences (Baek, 2013; Lankes, 2015). Most library staff receive no formal training in facilitating hands-on STEM activities, even if they have obtained a MLIS degree. They must instead rely on informal training from trusted groups like STAR Net and their own state libraries.

Furthermore, library professionals may feel that there are barriers or obstacles that prevent adoption of STEM programming (Hakala et al., 2016). As Lankes (2015) cautioned, public library staff need to see themselves as facilitators, not educators, of STEM learning to support STEM education (Mitchell et al., 2020). Factors such as staff capacity, library funding, administrative support, and community engagement may also influence whether libraries are able to implement effective STEM programs.

In such a challenging environment, building strategic partnerships can be a difference maker—as shown in the study of the RSC program (Jocz et al., 2021; Jocz & Greller, 2020). Through working together, library staff and engineers increased their knowledge and confidence in conducting programming for youth, making it more likely that libraries will continue to offer these types of experiences (Jocz et al., 2021; Jocz & Greller, 2020). Library staff gained a better understanding of engineering and what activities might be best for learning about the subject. Engineers learned how to facilitate activities with elementary children, and enjoyed reaching underserved audiences (Jocz et al., 2021). Given such enormous gains, the librarians may very well shift their preferences away from collaborating and performing to the making and discovering activities preferred by youth and engineers.

RSC has great potential for widespread adaptation, especially since it generated detailed curricular materials and instructional videos (Appendix). And public libraries are the right place for high-quality STEM programs. They have a large geographic reach and are widely utilized (Institute of Museum & Library Services, 2020) because they are
free, accessible (Shtivelband et al., 2019), and welcoming (Baek, 2013; Zickuhr et al., 2013). Libraries are vital spaces characterized by inclusivity and openness, capable of spanning the racial, political, and socioeconomic divides (Howard, 2019) that have historically limited access to STEM education and careers (National Center for Science & Engineering Statistics, 2021; Ong et al., 2020).

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Disclosure statement

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References


**Appendix**

*STAR Net STEM Activity Clearinghouse*: http://clearinghouse.starnetlibraries.org

Links to *Ready-Set-Create* Activities:
- Span-tastic Bridges: http://clearinghouse.starnetlibraries.org/136-span-tastic-bridges
- Clean Up Our World: http://clearinghouse.starnetlibraries.org/139-clean-up-our-world
- Designed to Survive: http://clearinghouse.starnetlibraries.org/137-designed-to-survive
- Power from Nature: http://clearinghouse.starnetlibraries.org/140-power-from-nature