The STEM Effect

An Action Agenda for Assessing the Long-term Impact of STEM Programs for Girls
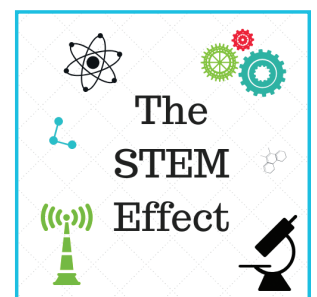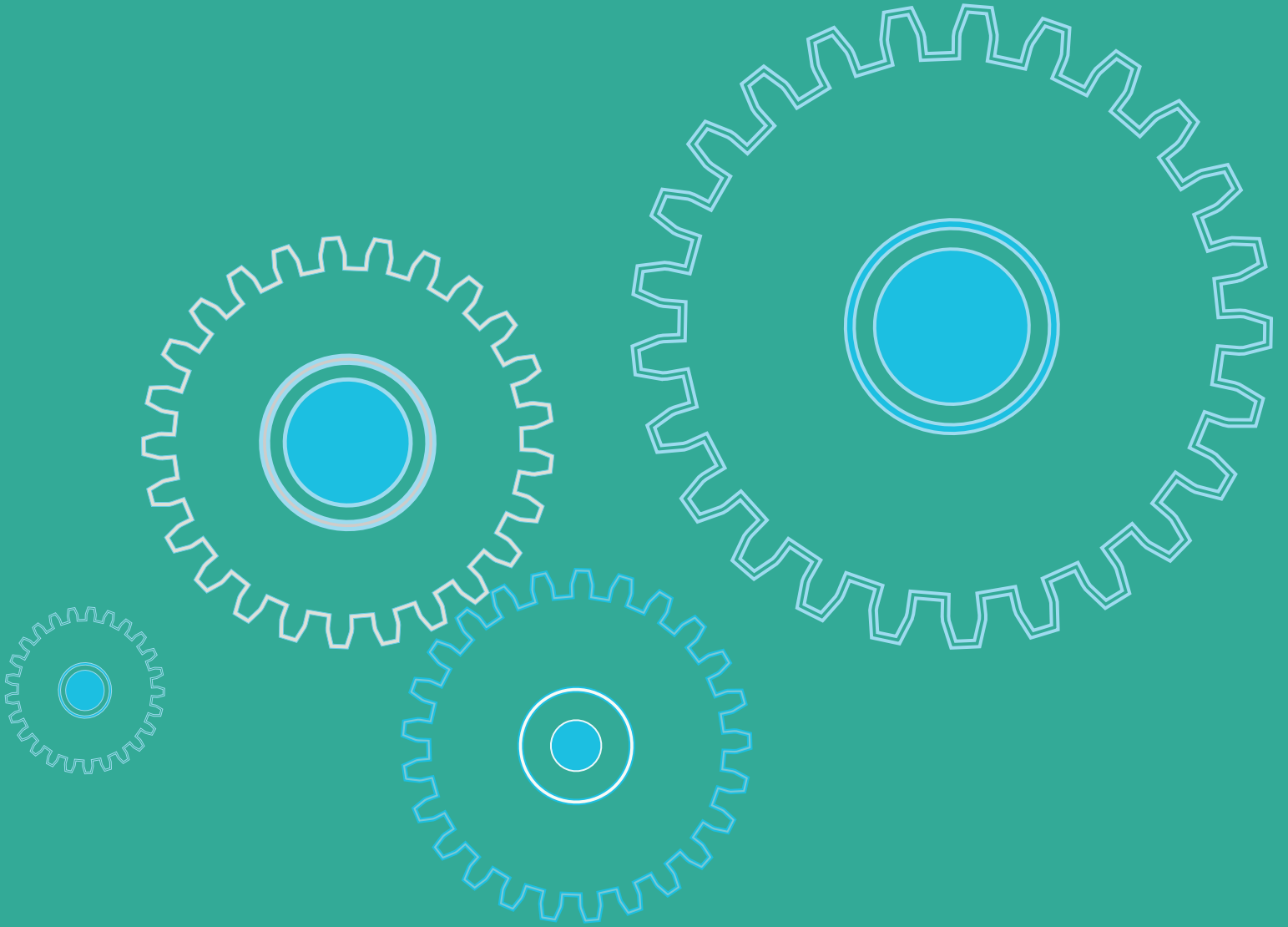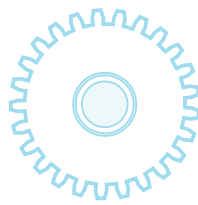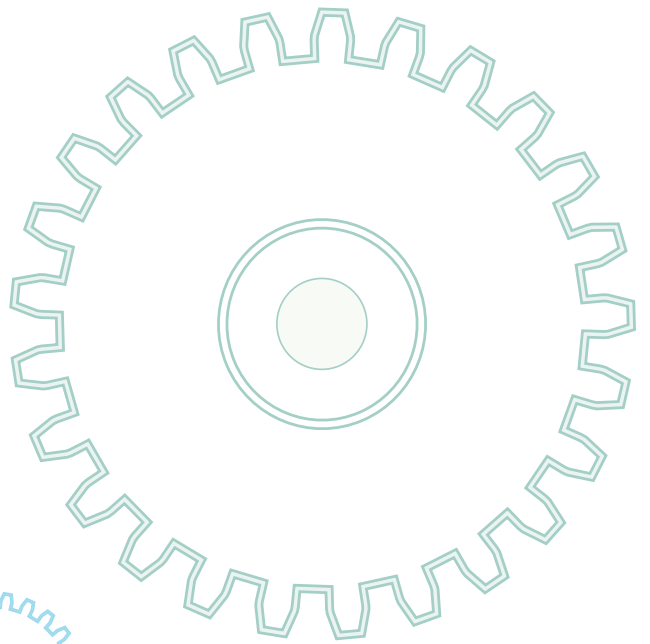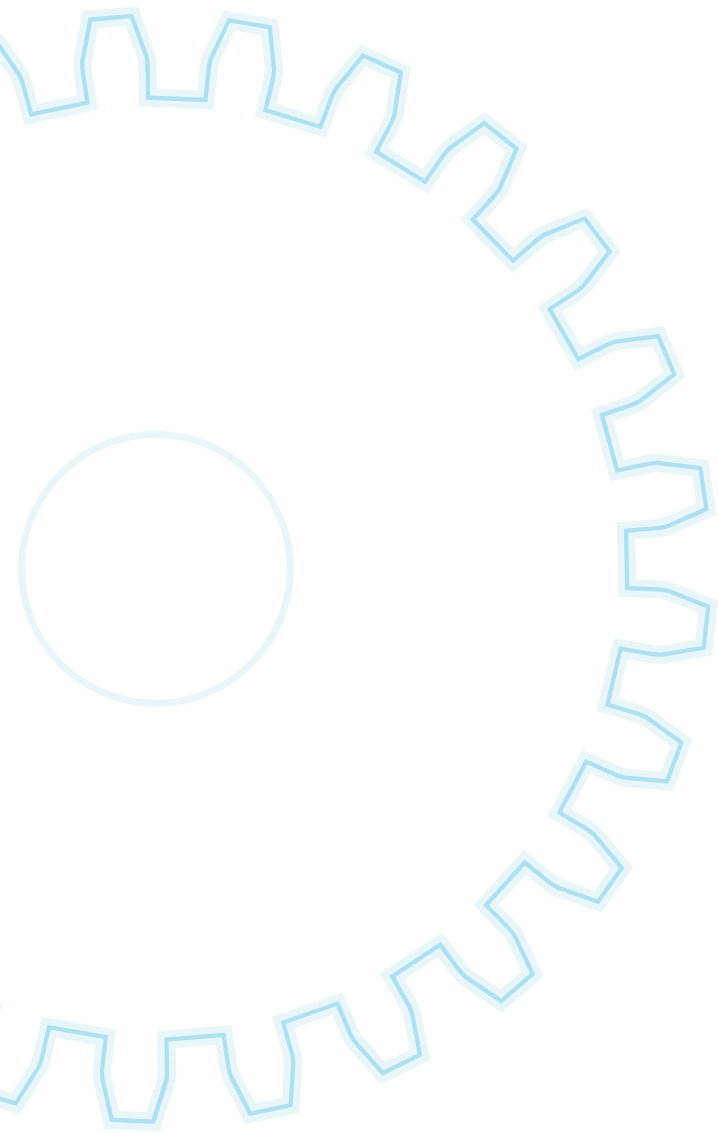
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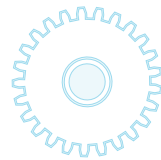
National Girls Collaborative Project

The STEM Effect

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The
STEM
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An Action Agenda

The purpose of this action agenda is to identify research questions and creative solutions for the longitudinal tracking of, and measurement of outcomes for, participants in girl-focused STEM programs[1]

This action agenda is intended to contribute to the collective knowledge of the impact of programs focused on fostering STEM readiness and a STEM career trajectory for girls—specifically programs hosted in cultural organizations (defined for this purpose as museums, science centers, zoos, botanical gardens and aquaria) and geared toward underserved populations. This action agenda will also serve as a framework for others engaged in this work, with the ultimate goal of addressing a major gap in our understanding of the mid- and long-term impacts of out-of-school-time (OST) STEM experiences for girls, particularly whether these experiences lead to an increase in their future participation in STEM studies and careers. To develop the action agenda we solicited input from representatives from cultural organizations across the country that provide programming aimed at increasing participation of girls and women in STEM. These representatives shared their experiences and existing approaches to the assessment of program outcomes. They were engaged with identifying and refining a set of research questions and identified opportunities as well as capacities for gathering and analyzing data.

The action agenda synthesizes what is known from previous research with what practitioners at cultural organizations care about and want to learn about their programs, as well as the challenges they face in understanding the long-term impacts of their programs. This report is organized into two parts. First, we hope to communicate the known facts about the program design more broadly to express what has shown to have the potential to produce positive long-term outcomes for girls. Second, we outline research strategies for further studies that are inclusive of a range of stakeholders. We believe these suggested approaches will help cultural organizations participate in high-quality research and also address many of the obstacles they face.

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[1]A girl-focused STEM program is designed based on principles that are known to be effective for engaging girls. Such programs may be attended by girls only, or by both girls and boys.

Need

While research on the short-term impact of OST STEM programs for girls and other underrepresented groups has shown promising results for individual programs, research on the long-term or even mid-term impact of OST STEM learning experiences for girls is limited. As stated in the latest report of the Committee on Successful Out-of-School STEM Learning (2015), the limitations of the existing research are due to the many types of OST STEM programs and the difficulties of measuring outcomes. Many programs in informal learning environments articulate the goal of having a long-term impact on the involvement of girls and women in STEM studies and careers, but for those whose programming interventions happen in early stages of development— elementary, middle, or high school—it is challenging to gather empirical evidence on the factors that lead to

Without this research, institutions and organizations do not have the information they need to ensure they are providing the kinds of experiences that adequately support girls along STEM career pathways.

positive mid-term (1 to 3 years after program completion) and long-term (3 or more years after program completion) effects on STEM engagement, activities and career interest among participants. Researching longitudinal impacts and outcomes of OST STEM programs is one of the top priorities for OST STEM education research by leaders in the field (e.g., Noam & Shah, 2013). Without this research, institutions and organizations do not have the information they need to ensure they are providing the kinds of experiences that adequately support girls along STEM career pathways.

Through convenings, Twitter chats, and focus groups held as part of the STEM Effect project, staff members from cultural organizations and other OST STEM programs identified challenges to the process of engaging in longitudinal research. Population transience, especially among low-income populations, logistical and ethical considerations associated with the collection of personal contact and academic information of minors, staff capacity and turnover, costs and program funding limitations all contribute to the overall challenge. Staff members from girl-serving STEM programs, as well as other stakeholders, were interested in hearing about the work that has already been/is being done and expressed excitement about recommendations for how to measure program impact long-term. We hope this action agenda will provide guidance to the community for overcoming some of these challenges and engaging in research efforts toward understanding how girls enter, persist, and thrive in STEM educational experiences and careers.

The Current Landscape

While many cultural organizations offer informal STEM programs, the types of programs offered tend to differ among museums, science centers, botanical gardens, zoos, and aquaria by content area and age group served. A survey of the landscape in the United States, performed through web search and the outreach efforts of the STEM Effect team, indicated aquaria, botanical gardens, and zoos are more likely to offer programs targeted at younger children (pre-school, elementary and middle school students); museums and science centers tend to target students from a broader age range, spanning from preschool to high school. Cultural institutions also vary in their approaches to working with girls in STEM. Some programs are intended only for girls, some are girl-focused while welcoming any gender, and some are aimed at any gender but remain primarily girl-serving as part of that more general audience. Program "touch" goes from one-day events to full summer-length, camp or afterschool programming formats, with programs for high-school-age girls often longer in duration (one week or longer) than programs for younger girls. Though many cultural organizations offer summer camps, museums and science centers are more likely to offer additional programs throughout the year. Many of the programs that cultural organizations offer for girls are being conducted in partnership with other organizations (e.g., nonprofits, YWCA, Girl Scouts, foundations).

Our analyses of 10 different logic models[2], collected from various OST STEM programs for girls, revealed that despite differences in STEM content, focus and age groups served, there was considerable overlap across programs in the kinds of short, medium-term and long-term outcomes they hope to achieve (if not actually measure). The primary short-term goals of STEM programs for girls offered by cultural organizations are to (1) introduce girls to STEM topics, (2) make girls aware that there are women in STEM, and (3) foster a community in STEM. Medium-term and long-term outcomes focus primarily on increasing girls' engagement and interest (e.g., in STEM topics, in taking STEM classes, in attending STEM-focused high schools, or college STEM programs) and behaviors (e.g., participating in other informal STEM programs, enrollment in STEM classes/programs, pursuing a STEM career).

For the purposes of this work, we cast a wide net of interest – but the action agenda is ultimately geared primarily for girls-only and girl-focused programs that supply a longer "touch" or "dosage" as research shows that program with at least 45 hours of interaction have more long-lasting positive impacts (Beckett, Borman, Capizzano, Parsley, Ross, Schirm, & Taylor, 2009).

Generalized Logic Model

RESOURCES >> Inputs	ACTIVITIES >> Strategies	OUTPUTS >> Tangible direct products of program activities	OUTCOMES >> Short-term	OUTCOMES >> Medium-term	OUTCOMES >> Long-term
What is invested? • Funding • Human Resources • Assets and artifacts housed at cultural organizations • Partners	**What we do:** • Camps • Semester-long programs • Year-long programs	**Tangible direct products of program activities** • Participation in program activities	**What results should as a direct result of the activities and outputs?** • Awareness, knowledge, understanding: STEM content, STEM career pathways • Engagement and interest: STEM content, STEM program participation, pursuit of STEM-focused college program and career • Skills: Content-specific skills, general	**What results should follow from the initial outcomes?** • Engagement & interest: STEM content, STEM program participation, pursuit of STEM-focused college program and career • Behaviors: Participation in other OST STEM programs, enrollment in STEM classes, attending specialized high schools, choosing a STEM major in college, and graduating college with a STEM major	**What results should follow from the initial outcomes?** • Engagement & interest: STEM content, STEM program participation, pursuit of STEM-focused college program and career • Behaviors: Attending and persisting in college, pursuing a STEM career, and participation in STEM programs for girls as role models, mentors and leaders

[2]A logic model describes the relationships between resources, activities, outcomes and impacts of a program.

Focus

The STEM Effect project was guided by the following questions: What program elements are effective in promoting girls' participation in STEM career pathways? What are the common data elements that we should assess across programs? What methods would be best suited to collect the relevant data? What are the resources cultural institutions would need to carry out effective longitudinal outcomes research?
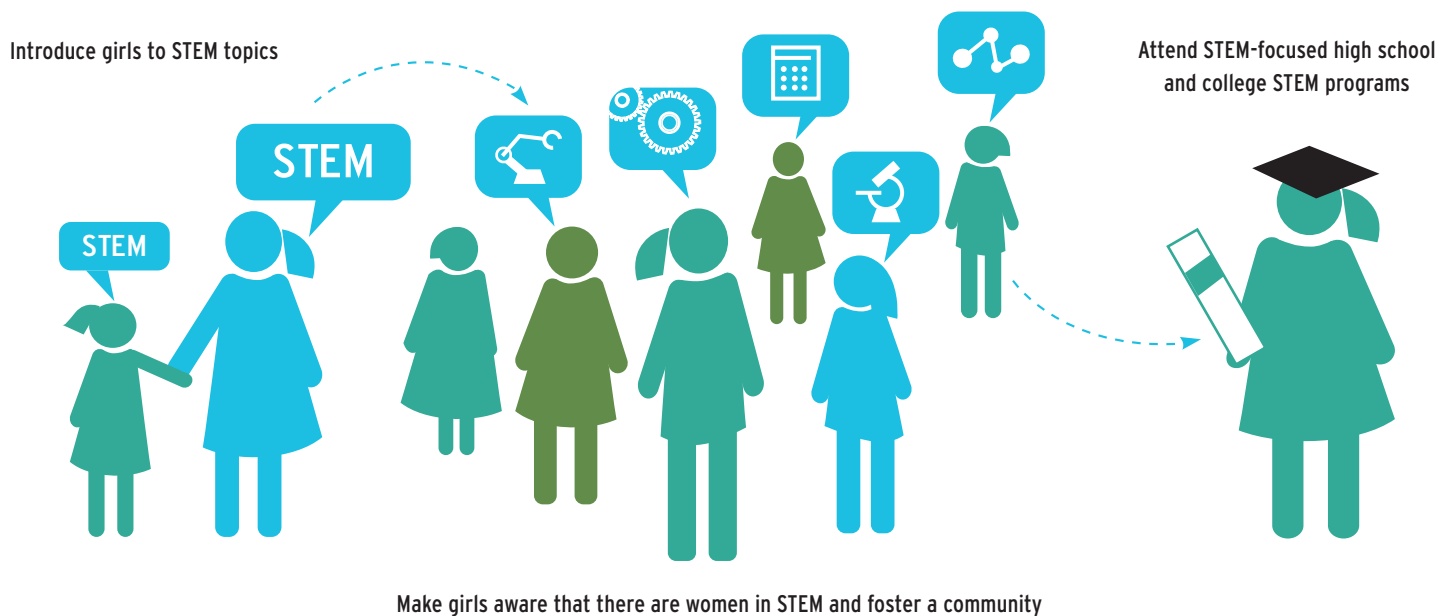
During the process of setting this research agenda, conversations with practitioners, researchers, and review of the research literature identified features of OST STEM programs that show promise for having positive long-term impacts on girls and youth as well as barriers that limit the impact of the STEM experience. Additional relevant questions and categories emerged which support and supplement the main research focus. These accommodated the wide spectrum of program types, inputs and gatekeepers, as well as critical junctures that influence girls' participation and persistence in STEM programs, education and careers. These supporting questions provide varied perspectives and entry points, revealing common data that can be tracked long-term, assessed and shared field-wide.

Elements of programs offered by cultural organizations that achieve long-term participation by girls in STEM programs and educational attainment:

- What are the unique contributions that girl-serving programs offered by cultural organizations make to impact STEM career decision-making and STEM career pathways?
- How do OST programs offered by cultural organizations help girls and young women develop social capital in STEM fields?
- What role do networks and interpersonal relationships play in STEM career trajectories for girls? How can OST programs for girls offered by cultural organizations help to nurture such networks and interpersonal relationships?

Supporting girls from non-dominant racial/ethnic groups in persisting on STEM career trajectories:

- What are effective strategies employed by cultural organizations in their OST STEM programs for girls that promote the participation of girls from non-dominant racial/ethnic groups in STEM career trajectories?
- What are the challenges that girls from non-dominant backgrounds encounter in pursuing STEM interests, and what can be done to overcome them?

Introduce girls to STEM topics

STEM

STEM

Attend STEM-focused high school and college STEM programs

Make girls aware that there are women in STEM and foster a community

Collaborations between STEM-rich organizations that support girls' persistence in STEM over the long-term:

- How can OST programs guide motivated girls to other formal/OST programs?
- What program activities can be used to guide girls and families where to go next, after they have completed a program?
- How can programs build partnerships to establish long-term STEM trajectories for girls?

Program elements shown in prior research as promising for longer-term impact:

Having clear missions and goals (McCreedy & Dierking, 2013) - It is important that organizations create STEM programs intentionally. Impactful programs have clear goals and missions (e.g., "build competence, confidence, and character"; "promoting recruitment of women in STEM"; "inspire girls to be strong, confident, bold"). Activities are designed to reflect this: WHAT girls would do, WHY they would do it, and WITH WHOM.

Establishing a community of practice/social network that can include parents, near-peers, counselors, STEM professionals, mentors and like-minded friends (McCreedy & Dierking, 2013; Melchior et al. 2018; Podkul et al. 2018). Girls need a meaningful and supportive community. They need to perceive that STEM programs contribute to their social capital (e.g., quality and quantity of relationships, resources available through social interactions), networks, and skills (e.g., STEM and life skills).

Providing personal development opportunities (internships, mentoring opportunities, teaching others, public speaking) (McCreedy & Dierking, 2013). Personal development opportunities help girls hone their skills, develop talents and reach their full potential. These experiences empower girls to take charge and assume leadership roles, while also helping them build competence, confidence, and self-awareness. These are key factors for a positive STEM student experience, and all contribute to the realization of girls' dreams and aspirations.

Offering shared inquiry-based hands-on activities, and unique learning experiences (field trips, museum experiences) (McCreedy & Dierking, 2013; Price, Kares, Segovia, & Loyd, 2019). These learning experiences help girls develop a sense of being someone who does science. It lets girls take ownership of their own learning and engage in meaningful STEM work, which helps them foster/maintain positive perceptions about STEM and develop a STEM identity.

Providing authentic science experiences (McCreedy & Dierking, 2013; Podkul et al. 2018). Engaging girls in authentic science experiences that incorporate practices (and tools) used by STEM professionals (e.g., asking scientific questions, designing and conducting research, building prototypes, testing hypotheses, communicating results) to positively impact their perceptions of STEM fields and their science identities. In an authentic science experience, girls solve problems in a context that is relevant to them (e.g., their lives and community). Examples of authentic science experiences include: working towards a solution of a real-world/community problem, using scientific instruments and technology, exploring, analyzing, and summarizing current data, communicating results to peers for constructive feedback, using appropriate math to analyze data, working with others in meaningful ways, etc.

Providing opportunities to develop twenty-first century personal and workplace-related skills (Melchior et al. 2018; McCreedy & Dierking, 2013). Fostering twenty-first century skills such as critical thinking, problem-solving, perseverance, creativity, teamwork, and communication help girls feel more empowered, build their confidence and motivation to persist in STEM, and further their personal development.

Incorporating elements of positive youth development (competence, confidence, connection, character, and caring) through relationships with staff (McCreedy & Dierking, 2013; Price, Kares, Segovia, & Loyd, 2019). Social relationships are crucial in girls' perceptions of STEM. Sustained adult-youth relationships that are supportive, communicate warmth, foster connectedness and good communication, increase girls' interest, motivation, and persistence in STEM.

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[3]Social capital refers to various factors that impact the effective functioning of social groups. They include such things as interpersonal relationships, a shared sense of identity, a shared understanding, shared norms, shared values, trust cooperation, and reciprocity.

Lowering barriers to participation (cost, transportation, financial incentives, etc.), particularly for teens (Terzian, Giesen, & Mbwana, 2009). Program fees and extra travel costs can be a deterrent to students from lower-income families, as can the need to find paid work.

Make a special effort to support girls and young women through the critical junctures (middle to high school, high school to post-secondary, post-secondary to career) when research shows the need for sustaining interest and engagement in STEM as they continue along their education path (Robnett, 2013; Dasgupta & Stout, 2014).

Challenges to long-term data collection and possible solutions:

Our conversations with stakeholders have also revealed the particular challenges that cultural organizations face when trying to collect data from participants after their programs end:

- The limited capacity of staff to work beyond delivering the programming, since funding is often intended for programs and short-term program evaluation, but not for research
- Staff turnover (including mentors)
- The transient nature of youth who move to different schools and neighborhoods
- The difficulty of keeping updated contact information for participants

Through our research with stakeholders, we have learned about several valuable strategies that OST programs use to overcome such obstacles:

1. They form partnerships with organizations such as the Girl Scouts of the USA and Boys & Girls Clubs of America, school districts, and institutions of higher education. This strategy enables cultural institutions to have more stable relationships with participants that can persist when a particular program ends. This tactic also allows cultural organizations to leverage those partners' abilities to stay in touch and keep track of the

program participants over time, so that researchers can conduct the necessary follow-up research.

2. They use digital platforms to stay connected with participants. Social media sites such as LinkedIn are designed for professional networking. OST program mentors reported that helping girls set up their LinkedIn accounts is a valuable part of their mentoring. Some organizations also have created the technical infrastructure to grant digital badges or micro-credentials for the completion of program elements and/or attainment of specific skills. These connections can enable researchers to follow the career trajectories of participants and can be a helpful way to stay in touch with program participants.

3. They introduce girls to professional associations. Many STEM disciplines have professional organizations; by introducing participants to these associations, and by encouraging them to join, OST programs can set girls on a pathway with ongoing access to professional relationships and opportunities. In addition, these professional organizations maintain databases of members. Researchers can work with these associations to recruit participants for the future data collection on programs in which members participated.

4. They collaborate with girls and families to shape programs and establish relationships that address the real needs they have and the challenges they face. Participants and their families share in devising methods for establishing long-term communications with the OST program staff and researchers that are mutually beneficial. Incentives such as information about other programs or professional opportunities, stipends for completing surveys and interviews, and community building through alumni events can motivate program participants to stay involved in the research. In addition, if participants and families help articulate the research questions, then there is a greater likelihood that they will want to stay involved to find out the answers.

PRIORITY AREA 1

Build knowledge about shared criteria across cultural organizations for common self-assessments and evaluation frameworks for their STEM programs, which will bolster the organizational capacity for undertaking long-term impact research and the compilation of data across organizations.

Research shows that shared definitions between organizations, across networks, and cross-sector collaborations support a scaffolded structure where the experience, expertise, and capacity of one organization or network can transform the work of others. Identifying commonalities across varied learning opportunities and program intentions (McCreedy & Dierking, 2013), offers organizations from regions of varying size a common way to contribute, learn, and receive assistance. As noted in Traphagen and Traill's, "How Cross-Sector Collaborations are Advancing STEM Learning," the 2014 paper commissioned by the Noyce Foundation, communities of practice provide support that addresses and meets the needs of varied organizations. It is these ecosystems that can aid collaborative opportunities for developing shared definitions, sharing tools and metrics, and contributing to a repository of learner data available to researchers and practitioners.

POSSIBLE RESEARCH PROJECT

A consortium of small-scale and rural science centers offering STEM programs, paired with a research team, develop common tools and metrics to assess the organization and program participants. This work would capitalize on practices and research already in the field, incorporate a research-practice structure, and lead to supporting evaluative practice and capacity where it does not already exist. There are other examples of researchers developing a common tool from different but related areas such as COVES (Collaboration for Ongoing Visitor Experience Studies). Supported by the Institute for Museum and Library Services, COVES is a shared instrument used across the museum field to collect data regarding visitor experiences. This proposed research project would culminate with the dissemination of a validated internal self-assessment of organizational capacity for tracking the long-term impact of their STEM program on participants, and the development of shared metrics and tools to capture data from participants at varying stages of their experience with the STEM program and afterward. Stages of this project would involve the following: a canvas study of small-scale and rural STEM organizations from across the country to determine existing evaluative capacities and gaps; the examination and refinement of the definition of "long-term," to be addressed by a common evaluation tool; mapping the shared needs among organizations regarding their capacity and intended program outcomes; and the design of a common tool for self-assessment and participant feedback. A data repository for those organizations able to share findings for collective analysis would also be developed. The tools and repository would be piloted and across varied organizations, followed by the testing of subsequent iterations until the self-assessment and participant tools are validated and the potential use for a repository is verified.

Research Questions Addressed

- What common data elements should be collected across organizations and programs?
- What is the range of evaluative capacities across organizations and programs?
- How can shared self-assessment tools for organizations offering STEM programs and program participants benefit the field and address the existing gap in evidence for understanding the long-term impact of STEM programs on girls?
- How can this model for shared tools be sustainable?

Outcomes Measured

- Evaluative capacity and needs of cultural institutions offering STEM programs to track long-term impact on participants

Role of Practitioners

- Engage in institutional self-assessment of evaluative capacity
- Pilot and use self-assessment tool
- Pilot and use shared metrics to track and assess long-term impacts on program participants
- Share results for collective analysis
- Review results and share insights

Role of Researchers

- Develop a self-assessment tool based on research-practice evidence, gaps in evidence and cultural organization needs
- Pilot, test and iterate tools and the data repository during its refinement
- Recruit cultural organizations and administer surveys
- Analyze data and share results with cultural organizations

PRIORITY AREA 2

Build knowledge about what kinds of supportive relationships help girls continue on STEM trajectories.

Girls need a meaningful and supportive community. They need to perceive that STEM programs contribute to their social capital (e.g., quality and quantity of relationships, resources available through social interactions), networks, and skills (e.g., STEM and life skills). Social relationships are essential in developing girls' perceptions of STEM. Sustained adult-youth relationships that are supportive, communicate warmth, foster connectedness and good communication, increase girls' interest, motivation, and persistence in STEM (McCreedy & Dierking, 2013; Melchior et al. 2018; Podkul et al. 2018; Price, Kares, Segovia, & Loyd, 2019).

POSSIBLE RESEARCH PROJECT

A science center with the capacity to offer two sessions of the same girl-focused computer science (CS) program for high school students (or two science centers with similar girl-focused CS programs) asks participants to create LinkedIn profiles, letting them know that they will be used for data collection and also for sharing future program and internship opportunities. Both programs feature in-person mentors to check with participants throughout the program, with one program asking participants to join a professional organization for women in CS as one of their activities, and then to initiate relationships with association members and question them about CS careers. Using the LinkedIn connection, researchers monitor the information that program participants post about their educational and OST activities and administer yearly surveys that ask the participants about their career interests and connections to mentors or association members. At the end of four years, researchers analyze the data to determine which condition resulted in more positive outcomes.

Research Questions Addressed
- How do OST programs offered by cultural organizations help girls and young women develop social capital in STEM?
- What role do networks and interpersonal relationships play in STEM career pathways for girls? How can OST programs for girls offered by cultural organizations help to nurture such networks and interpersonal relationships?

Outcomes Measured
- Persistence of girls' STEM career interest
- Girls' persistence in and their perceived value of the mentor relationship
- Girls' persistence of engagement in STEM programs
- Girls' educational attainment

Role of Practitioners
- Implement programs with different mentoring conditions
- Have participants create LinkedIn accounts
- Communicate with participants over LinkedIn about future program opportunities

Role of Researchers
- Design research plans with different mentoring conditions
- Maintain a database of participant data over time
- Annually administer surveys to participants
- Analyze and share findings with science centers and participants
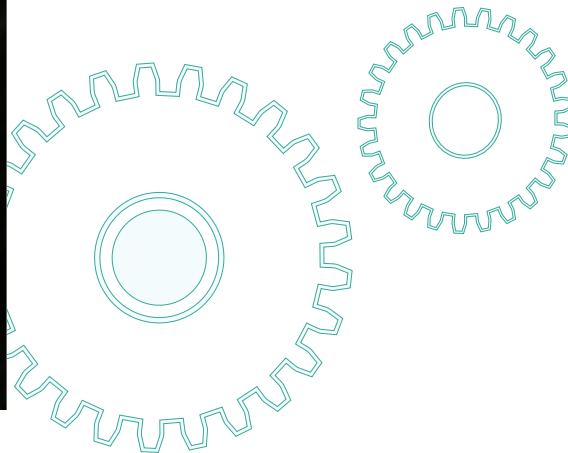
PRIORITY AREA 3

Build knowledge about how to design programs that support girls from non-dominant racial/ethnic groups to stay involved in STEM programs.

Intentionality is a critical component in the design and implementation of OST programs that effectively engage girls from non-dominant ethnic groups in STEM. Programs that are culturally responsible and gender equitable are more likely to succeed in engaging minority girls in STEM learning and help them develop a sense of belonging in these fields. Research shows that programming efforts should focus on fostering family involvement and emphasizing family values, supporting social relationships, teamwork, and group learning (Adams et al. 2014; Cakir et al. 2017; Price, Kares, Segovia, & Loyd, 2019; Riedinger & Taylor, 2016; McCreedy & Dierking, 2013; Sammet & Kekelis, 2016; Weisgram & Diekman, 2017).

POSSIBLE RESEARCH PROJECT

A STEM-rich institution offers two sessions in one year, of the same program designed for girls from non-dominant groups. It partners with Girl Scouts of the USA, an organization that has the capacity to keep track of the girls and has established connections to families. In one session, the program is delivered with a family orientation that explains the program at the beginning and a culminating family event at the end. The second session involves the family throughout the program. In the beginning, the orientation is designed to ask the girls and families about their STEM interests and education goals, and the ways which the program can help the families achieve those goals. During the program, the museum provides two additional sessions of programming as requested by the family, such as STEM college and career information or financial aid planning. At the culminating event, girls and families come up with ideas for maintaining contact for mutually beneficial communication—participating in longitudinal data gathering as well as receiving information about internship and program opportunities and alumni events. Researchers conduct structured interviews with the girls and a family member while the program takes place. They also work with the Girl Scouts of the USA to keep track of the families in both conditions, so that they can conduct follow-up structured interviews with girls and family members each year for the next three years to monitor the outcomes for the girls and families in the two conditions.

Research Questions Addressed

- What are effective strategies employed by cultural organizations in their OST STEM programs for girls that promote the participation of girls from traditionally underrepresented groups in STEM career pathways?
- What are the challenges that girls from different backgrounds encounter in pursuing STEM interests, and what can be done to overcome them?

Outcomes Measured

- Persistence of girls' STEM career interest
- Families' knowledge of STEM programs and educational opportunities
- Girls' persistence of engagement in STEM programs
- Girls' educational attainment

Role of Practitioners

- Establish a recruitment partnership with Girl Scouts of the USA
- Implement programs with different family involvement conditions
- Provide additional information based on the expressed interests of families
- Communicate with participants and families about future program opportunities

Role of Researchers

- Design research plan with different family involvement conditions
- Establish a data sharing partnership with Girl Scouts of the USA
- Conduct structured annual interviews with girls and family members
- Analyze data and share findings with the museum and families

PRIORITY AREA 4

Build knowledge about the unique program elements that cultural organizations can offer and that inspire girls to persist on STEM career trajectories.

Existing research indicates that programs that offer girls hands-on activities and authentic science experiences and twenty-first century skills can increase their interest and persistence in STEM. A research project that provides a variety of STEM work experiences, and measures their differential impact on girls' educational and career choices, could prove valuable to cultural institutions that wish to better understand the most impactful kinds of programs for girls with various interests (McCreedy & Dierking, 2013; Melchior et al, 2018; Podkul et al, 2018; Price, Kares, Segovia, & Loyd, 2019).

POSSIBLE RESEARCH PROJECT

A natural history museum partners with a school district and city youth employment office to offer three summer programs to low-income girls who are between their sophomore and junior years of high school (the girls are paid to participate since they might otherwise choose to get summer jobs). One program has the girls work on a collaborative team to learn digital design skills as they create a new virtual exhibit that will be on the museum website; another has girls work with staff scientists on authentic data collection, documentation, and analysis; the third has the youth work as docents for exhibits, a task that requires them to learn about the exhibit content in-depth and practice their public-speaking skills. Girls take a survey about STEM interests prior to participation and then would be randomly assigned to the conditions to ensure that each program features a mix of girls with and without STEM interests. Researchers conduct a mixed-methods study, observing how each program is implemented, collecting baseline data from the school district on the girls' grades and courses, and following their educational attainment and course choices over time. Researchers will also survey the girls about their STEM and career interests, and which aspects of the program they found most meaningful after the program and after each year of high school, into their post-secondary education or employment. Researchers then analyze the data to see if there are important differences in outcomes for girls for the three designs.

• What are the unique contributions that girl-serving programs offered by cultural organizations make to STEM career decision making and STEM career pathways?
• Among women who study STEM in college, how did participation in girl-serving OST programs offered by cultural organizations help them to persist in their studies?
• How do OST programs offered by cultural organizations help girls and young women develop social capital in STEM?

Outcomes Measured

• Development and persistence of girls' STEM career interests
• Girls' knowledge of STEM programs and educational opportunities
• Girls' persistence of engagement in STEM programs
• Girls' educational attainment and high school/college course selection

Role of Practitioners

• Establish a partnership with the school district and youth employment office
• Work with different museum departments (exhibits, communication, the scientists) to design different summer programs
• Implement summer programs with three different conditions

Role of Researchers

• Design research plan with varying conditions of implementation
• Establish a data-sharing partnership with school districts
• Survey and randomize girls at the beginning of the program
• Conduct surveys over four years with the girls/ young women
• Analyze data and share findings with the museum, school district, youth employment office, and girls/young women

Research Questions Addressed

PRIORITY AREA 5

Build knowledge about establishing relationships across cultural and educational institutions to help girls persist in STEM, especially through critical junctures research, which is key to supporting girls on long-term trajectories.

Much of the research on broadening the participation of women in STEM focuses on how to engage young women at a specific educational level (e.g., elementary, middle, high school, or college). Interestingly, research indicates that girls leave STEM at different key transition points: middle school to high school, and high school to college/CTE (Cheryan, Master & Meltzoff, 2015; Dasagupta, & Stout, 2014; Shapiro, Grossman, Carter, Martin, Deyton, & Hammer, 2015). Much of the STEM interest and engagement is lost at these key transition points. Thus, it is important to pay attention at critical junctures in girls' educational pathways. We need to better understand the factors (e.g., gatekeepers) that are keeping girls away from STEM, as well as opportunities that they face at these critical junctures, to be able to provide the appropriate support (See Figure # Critical Junctures at right).

POSSIBLE RESEARCH PROJECT

In a city with many cultural institutions that offer maker spaces and engineering education programs, establish a relationship with a university that has an engineering school, to map out possible engineering career trajectories for girls. These can start with making projects for middle school students to spark interest in engineering topics, moving to robotics or other building projects in high school that introduce them to the engineering design process, and lead to entry into engineering programs and eventually degrees from the participating university. Researchers can engage in a mixed-methods study that documents the process of program coordination across the different institutions, and follows different cohorts of girls as they move, or do not move, from one program to the next, and documents their educational course choices in high school and college over time.

Research Questions Addressed
- How can informal programs guide motivated girls to other formal or informal programs?
- What program activities can help girls and their families know where to go next after having completed a program?
- How can programs build partnerships to establish long-term STEM trajectories for girls?

Outcomes Measured
- Capacity of institutions to work toward a common goal
- Capacity of institutions to coordinate efforts
- Persistence of girls' STEM career interest
- Girls' knowledge of STEM programs and educational opportunities
- Girls' persistence of engagement in STEM programs
- Girls' educational attainment

Role of Practitioners
- Establish partnerships with other cultural organizations and universities
- Engage in the process of mapping engineering trajectories and design programs accordingly
- Guide participants to next phases of the trajectory

Role of Researchers
- Engage with practitioners from all institutions to develop a logic model
- Conduct observations and interviews to document the process of trajectory development and implementation
- Conduct observations and interviews to document participant experience
- Analyze data and share findings with institutions and participants

Critical Junctures in the STEM Pathways for Girls

Barriers	Input
Math fluency and methods for teaching math	Family support, pop culture / media, proximity to cultural assets and resources

Barriers	
Self-efficacy, STEM stereotypes about race and gender, choices for participation in STEM programs	

CRITICAL JUNCTURE
Choosing STEM programs / focused classes in high school

Barriers	Input
Availability of STEM programs. STEM stereotypes about race and gender, financial responsibility	Family support, Mentors / Advisors / Teachers, proximity to cultural assets and resources

Barriers	Input
Nature and relevance of STEM programs / applicability of STEM, STEM stereotypes about race and gender	Female peers, formal in-school and after-school clubs / programs, out-of-school time opportunities

CRITICAL JUNCTURE
Persistence to college

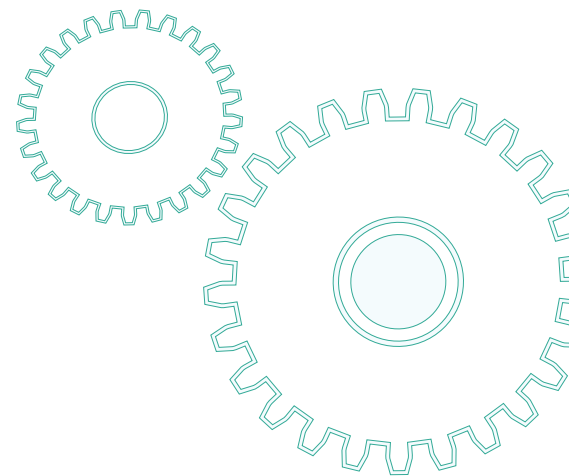| Barriers	Input
Self-efficacy, STEM stereotypes about race and gender	Female peers, meeting female STEM professionals, STEM networks, family support

CRITICAL JUNCTURE
Selecting STEM majors

CRITICAL JUNCTURE
Entering and remaining in STEM career

	Input
	Female peers meeting female STEM professionals, STEM networks, opportunities to give back to a young girl / woman interested in STEM

Input

- Family support
- Pop Culture / Media
- Proximity to Community Cultural Assets
- Access to advanced classes
- Mentors / Advisors / Teachers
- Female peers
- Formal in-school and after school clubs / programs
- Out-of-school time opportunities
- Nature and relevance of STEM programs / applicability of STEM
- Meeting female STEM professionals
- STEM networks
- Opportunities to give back to a young girl / woman interested in STEM

Critical junctures in the STEM pathways for girls

From our conversations with researchers, practitioners, and a review of the literature, a key lesson we learned is that creating a STEM environment where diverse girls and young women feel they belong and can succeed is crucial to solidify their interest and maintain their STEM presence throughout their education and career. This sense of belonging is particularly important for girls from underrepresented racial and ethnic minorities. Belonging, or feeling that they fit, seems to be a critical factor that determines whether a girl continues to pursue STEM. Fostering a sense of belonging is an interesting and potentially powerful method to bridge critical junctures in STEM education pathways for girls effectively. How can STEM programs at cultural organizations help foster girls' sense of belonging, and how do we maintain that sense of belonging over the long term? Several of the promising program elements for long-term impact previously mentioned, provide girls with socio-emotional support that helps them develop a strong sense of belonging in science. Other examples of effective strategies used by OST programs that foster a sense of belonging in STEM (See Santiago, et al. 2019) focus on making STEM meaningful to girls by engaging them in activities that draw on their interests, knowledge, skills, culture and lived experiences (Boucher et al. 2017; Sammet et al. 2016); empowering girls to embrace struggle, overcome challenges, and increase self-confidence in STEM (Blackwell et al. 2007; Dweck, 2000; Halpern et al. 2007); encouraging girls to identify and challenge STEM stereotypes (Allen et al. 2017; Carli et al. 2016; Cheryan et al. 2015; Sammet et al. 2016; Boucher et al. 2017); emphasizing that STEM is collaborative, social and community-oriented (Capobianco et al. 2015; Diekman et al. 2015; Leaper, 2015), and providing opportunities for girls to interact with and learn from diverse STEM role models (Koch et al. 2015; Leaper, 2015; Adams et al. 2014; Jethwani et al. 2017). The above strategies have been used by several OST programs to engage middle-school-age girls in STEM and help them develop a sense of belonging in these fields (Santiago, Pederson, & Karl, 2019). An overarching framework that could help retain girls in STEM at critical junctures in their education is to develop a STEM learning ecosystem that would bring together various stakeholders to develop and sustain learning opportunities in STEM (See Priority Area 5).

Conclusion

Drawing on input from practitioners from cultural organizations and researchers, we have identified a set of research questions and possible action steps to address them, in an effort to move our field forward in better understanding the long-term impacts of STEM programs for girls. The sample research projects described above are not meant to be exhaustive; rather, they are intended to describe doable possibilities, and we hope that they will inspire the field to conduct research along these lines and collaborate in the process of enhancing the knowledge base on how cultural organizations can contribute to girls' long-term pursuit of STEM pathways.
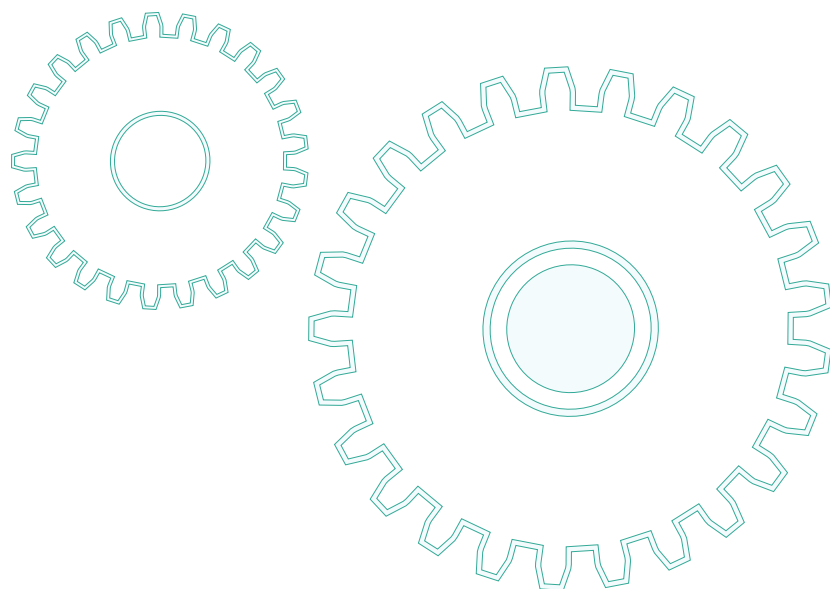
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4. ADDITIONAL RESOURCES

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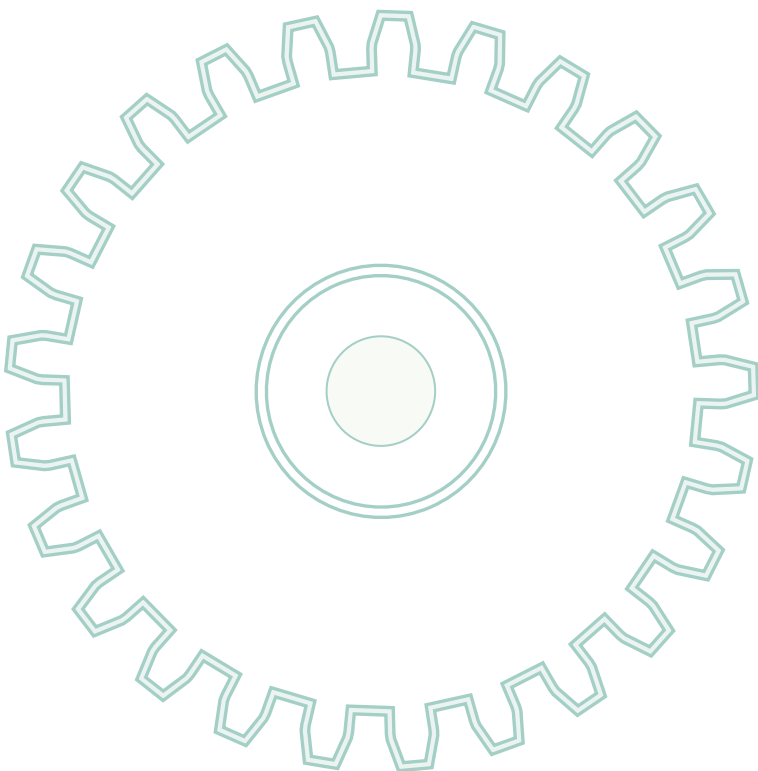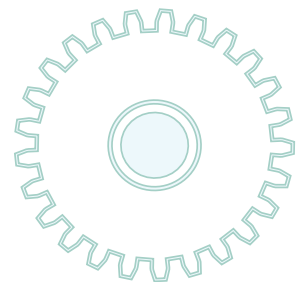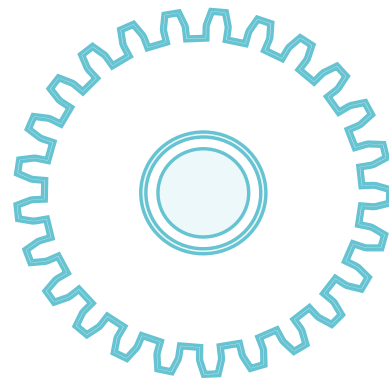
The Stem Effect

Developing an action agenda to better understand mid-and long-term impact
of STEM programs for middle and high school girls at cultural institutions.

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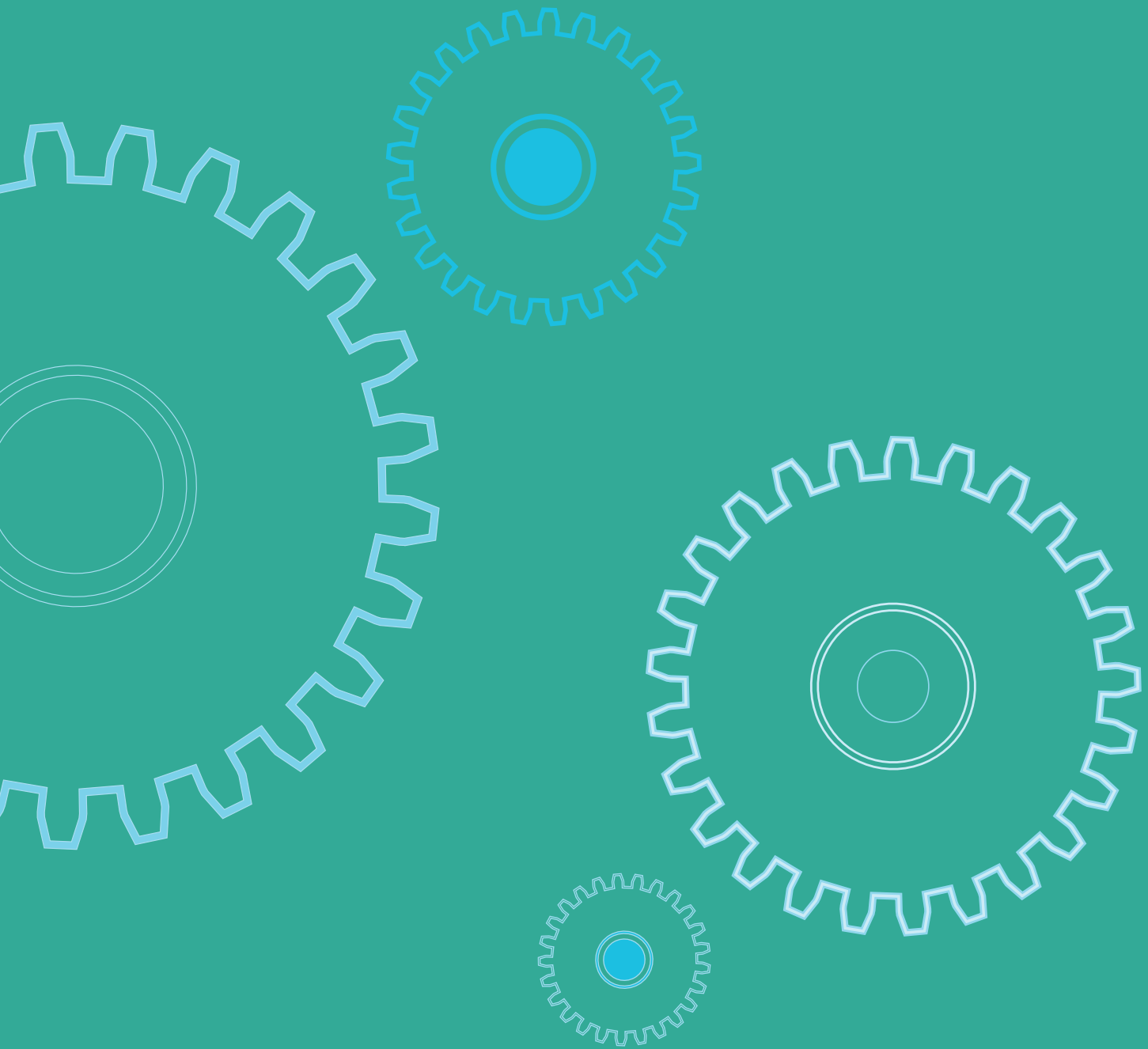**John Easton,** PhD, UChicago Consortium on School Research

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