# Engaging Youth in Science Research, Communication, and Education to Foster Identity Development

***A Resource Toolkit***

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# Executive Summary

## TSRCP (Teen Science Research, Communication & Education Program)

The Teen Science Research, Communication & Education Program (TSRCP) described throughout this toolkit was designed to engage young people in a variety of aspects of science—with an emphasis on experimental research—through training, mentorship and immersion in science communities.

The TSRCP piloting effort was funded by the National Science Foundation (*Developing A Program Model for High School Science Research, Communication and Education Experiences in Living Laboratory*; DRL-1811276). The project paired informal science learning and research (led by the Museum of Science, Boston; Becki Kipling, PI) with experimental psychology research (led by Boston University; Dr, Peter Blake, co-PI) and evaluation (University of Pittsburgh, Dr. Katie “KT” Todd) to test the program.

TSRCP piloting involved two cycles of a year-long program, during which teens:

1. Engaged in research practices,
2. Engaged in science communication practices,
3. Engaged in science education practices,
4. Experienced mentorship from STEM professionals, and
5. Became paid members of scientific communities.

Evaluation across two pilot cohorts found that the program elements collectively promoted youth identity development, leading youth to better differentiate and articulate their interest and affinity for different aspects of science and their own relationship with science practices and science communities. Project outcomes, as well as products, are shared at: Developing A Program Model for High School Science Research, Communication and Education Experiences in Living Laboratory↗.

## Living Laboratory

TSRCP builds on the Living Laboratory® model of partnership, which fosters collaboration between museums and research organizations to study human subjects (e.g., cognition, emotion, learning, and health) while simultaneously engaging the public in education and science communication about these topics. Through mutual professional development activities between researchers and museum professionals, Living Laboratory provides tools and processes through which researchers learn about and practice informal education and science communication strategies, while museum staff and visitors gain insights about the latest research happening in their own community.

The model centers on researchers conducting their studies in public spaces, providing opportunities for museum visitors to learn about researchers' on-going work as they participate in active experiments or activities that illustrate research processes. Museum educators also engage visitors in hands-on activities that demonstrate research methods and findings. The Museum of Science, Boston launched its Living Laboratory program in 2005 and, with significant investment from the National Science Foundation (DRL-0714706, DRL-1113648; DRL-1640726), the model expanded to more than 30 sites around the country. To learn more about the Living Laboratory model, visit: www.livinglab.org↗

## References:

Beaumont, L., Todd, K., Pfeifle, S., & Lindgren-Streicher, A. (2016). National Living Laboratory: Creating Communities of Learners for Informal Cognitive Science Education: Summative Evaluation Report. Ann Arbor, MI: Evergreene Research & Evaluation.

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Soren, B.J. (2009). Summative evaluation of "A Participatory Model for Integrating Cognitive Research into Exhibits for Children," (NSF grant # 0714706).

## TSRCP Toolkit

This document synthesizes elements of a curriculum that was implemented with two cohorts of youth participants, with each cohort participating over the course of one year. The pilot project was interrupted and impacted by the COVID-19 pandemic. As a result, the project team pivoted to implement portions of both cohorts as a virtual on-line experience and investigated two program timelines: one in which youth began the program with a summer intensive and another in which youth's experiences culminated in a summer intensive. This document is not a comprehensive curriculum, but instead aims to offer guidance and resources to museum educators or researchers interested in collaborating to offer youth work-based learning experiences with training and mentorship in science research, communication, and education.

This toolkit is intended to be a living document that reflects the lessons learned from many rounds of development, implementation, and iteration with youth. The most up-to-date version of the resource toolkit can be found at: Developing A Program Model for High School Science Research, Communication, and Education Experiences in Living Laboratory↗

For more information, please contact the project team at livinglaboratory@mos.org. We are eager to connect with interested individuals and organizations, especially to discuss additional resources that could be added in support of future partnerships.

# Toolkit Structure and Nomenclature

This toolkit is organized in five thematic sections, aligned with the program elements:



Several different types of tools were used in the planning, implementation, and evaluation of the TSRCP piloting effort, each of which is described briefly below.

| | |
|---|---|
| **Programmatic Tools**<br>*Mentor-facing* | Module – A module consists of specific goals, activities, tools, and resources that address a theme within the program. These summary planners offer suggestions for achieving each goal within the module. Introductions to each module are followed by the specific tools related to that module, with links to relevant resources embedded throughout.<br><br>Organizing Tool – These tools are used, primarily by mentors, to help plan and sequence youth activities in the program. Many of these tools share implementation tips or lessons learned from the perspective of a TSRCP mentor or evaluator.<br><br>Resource List – These tools outline materials, resources, and/or projects the team was inspired by or used in one of more aspects of the program.<br><br>Discussion Guide – These tools suggest guiding questions a facilitator (typically the mentor) can ask youth; sometimes these tools include framing or context for the conversation to be had.<br><br>Activity Guide – These tools provide step-by-step instructions to mentors for creating an experience with youth. |
| **Programmatic Tools**<br>*Youth-facing* | Handout - A document that provides information to youth.<br><br>Worksheet - A document used by youth to record and organize their ideas. |
| **Evaluation Tools**<br>*Evaluator-facing* | Surveys, Interviews, or other protocols used by evaluators to collect data from youth. |

# 01 | Community Building and Mentorship

## **Welcoming Youth to Workplaces** | Organizing Tool

TSRCP piloting involved youth (high school students ages 14-19) as Museum of Science employees ("Research and Science Communication Assistants"), who were co-appointed as research assistants for the Social Development & Learning Lab at Boston University as part of their job responsibilities. This document outlines considerations for welcoming youth participants to a program that occurs across two institutions (e.g., a museum and a university) with lessons learned from implementation with two cohorts of youth. It is important to reflect on the logistics of orienting minor employees who will collaborate using technical and other systems operated independently by two different organizations, and who will be mentored by multiple professionals operating in different organizational cultures.

### Defining Youth as Personnel

- Decide how youth participants will be positioned in both organizations, and the duration of their tenure (see **TSRCP Program Timelines** for suggestions). Consider whether youth will be hired as personnel at both institutions or hired by one institution and positioned as a consultant, independent investigator, volunteer, or other defined role at the second institution. This decision will require internal consultations at both organizations to understand considerations such as the organizations' HR policies, funding workflows, available space and equipment, and any prior organizational relationships with youth communities.

- Define an appropriate number of youth participants for the program, based on institutional capacity, funding availability, programming needs. Consult with others at your organization to determine other factors to consider. During TSRCP piloting, the project team supported training, mentorship, and opportunities for authentic project work at their institutions with cohorts of six youth at a time.

- Identify any pre-requisite skills, knowledge, or other minimum requirements for youth to be successful in the program (e.g., comfort working with children, interest in conducting research), and define what opportunities the program will provide for learning and growth.

- Co-create a job description (see **Youth Job Description**) that describes expectations and specific accountabilities youth will have to each of the institutions.

- Include youth as investigators on Institutional Review Board (IRB) documentation the study's PI submits to their governing IRB. This may involve youth completing agreement forms, submitting proof of research ethics training, or providing personal information to the IRB.

- Ensure youth have access to reliable workspaces and technology (e.g., desks, laptops, storage space), as well as any necessary communication systems, file storage, and software (e.g., Microsoft Office, Google Drive, RStudio, Slack, institutional email server access)

## Preparing for Co-Mentorship

- Ensure mentors receive reciprocal orientation to policies and systems related to youth employment and organizational access across both institutions. For example, mentors may be officially designated as volunteers, consultants, or another role at one another's institutions in order to receive appropriate access and permissions (e.g., badge or keycard access, software licenses, institutional user accounts).

- Make decisions about shared software, online platforms, communication strategies, and other logistical matters in advance. To best support youth, it is important for mentors to build shared understanding of how and where work will happen and communicate in consistent ways.

## Front End Training with Youth

- Host a shared orientation meeting or workshop to introduce youth to the policies of each institution, support understanding of the collaboration between the institutions, and kick off development of a sense of community (see **Orienting Youth to Organizations** for a suggested orientation outline).

- Identify key areas of learning to prioritize for youth in the first few sessions of the program. This may include sharing information about institutional policies, wayfinding for themselves and to support museum guests, and ethics training.

## Working with Minors

- Communicate with both institutions' Human Resources personnel to determine what additional practices (and what paperwork!) may be involved in hiring and supervising minor employees. Youth hiring processes at the Museum of Science (located in Massachusetts) required youth to complete tasks such as a CORI/SORI check (for those over 18), presenting proof of vaccination, presenting a work permit signed by school administrators, and possessing a federal or state ID.

- Identify any additional forms or permissions youth or their guardians may need to complete in advance of participation in the program (e.g., consent/assent to participate in program evaluation, parent/guardian permission for field trips or other off-site events).

- Develop a thorough understanding of youth labor regulations for your institution - most states limit the number of hours, specific times of day, or kinds of work that minors (under 18) may engage in. The Department of Labor's website↗ has a number of good resources outlining any rules or other considerations to take into account.

## **Youth Job Description** | Organizing Tool

This resource shares sections of the job description used to recruit, select, and hire youth during TSRCP piloting.

**Position Title:** Research and Science Communication Assistant

**Position Summary:**
The Research and Science Communication Assistant (RSCA) will work closely with small teams of peers, under collaborative mentorship from Boston University researchers and Museum of Science staff, to engage families in learning about current research topics as part of their museum visit. The RSCA will complete training in experimental psychology research methods, science education strategies and science communication practices, with a focus on the science of child development. The Research and Science Communication Assistant will develop skills related to designing and conducting a child development research study, including those needed to develop and execute a research protocol, analyze data, and present research findings for both public and professional audiences. They will gain practical experience through direct interaction with the public, including recruiting museum visitors to participate in studies, collecting data, and talking with families about study questions, methods, and implications. The RSCA will also engage museum visitors in learning about research topics by facilitating small group activities for families, as well as developing and prototyping educational products such as hands-on activities and caregiver handouts for use in the Museum.

**Dimensions:**

- Develop and maintain familiarity with best practices for experimental psychology research, science education and science communication with museum audiences
- Interact directly with Museum visitors as a researcher, working closely with mentors (from the Museum and Boston University) to recruit families and conduct research studies with children and their caregivers
- Interact directly with Museum visitors as a science educator and science communicator, with a focus on sharing on-going Museum-based research initiatives with families
- Support the day-to-day operation of the Museum by assisting with cleaning, organization, and upkeep of educational materials and exhibit venues
- Support development of research questions and procedures for a novel study, as well as 1-2 research products (e.g., study pre-submissions, academic posters) per year.
- Develop 3-4 educational products (e.g., caregiver handouts, hands-on activities) per year.
- Communicate research findings to professional audiences (e.g., other museum staff, other researchers), verbally or in writing, approximately three times per year.

**Accountabilities:**

1. Learn and practice science research skills and techniques by observing studies, collecting, and analyzing data, and reporting on the outcomes of experiments, under mentorship by Boston University researchers and staff in the Museum's Learning and Research division.
2. Learn and practice science education and science communication skills and techniques by engaging families in learning about child development methods and findings (e.g., through hands-on activities, demonstrations, presentations).
3. Develop novel research products (e.g., study pre-submissions, academic poster) and educational products (e.g., caregiver handouts, hands-on activities) and disseminate these to professional and lay audiences, in order to effectively communicate child development research methods and findings with other professionals and with the public.
4. Assist in ensuring high-quality STEM learning experiences in the Museum, by facilitating activities for visitors and providing logistical support (e.g., helping maintain exhibit spaces, documenting activities, assisting with materials management).

**Minimum Qualification:**

- Ability to read, write, and understand English. Basic math skills.
- Demonstrated comfort communicating STEM concepts to a variety of lay audiences verbally.
- Demonstrated interested in psychology, child development or a related field of research.
- Demonstrated interest in science education and/or science communication.
- Demonstrated interpersonal skills and ability to work in a group setting as part of a multi-faceted team.
- Must be a rising sophomore, junior or senior in high school.
- Availability 4 days/week in summer and either Saturdays or Sundays during the following academic year.

**Special Skills:**

- Demonstrated familiarity with word processing and spreadsheet software
- Demonstrated familiarity with informal science education practices
- Demonstrated familiarity with psychology research methods

**Commitment:**

- 28 hours/week in summer (4 days; late June - late August)
- 7 hours/week (1 day; Saturday or Sunday) during the following academic year

## **Orienting Youth to Organizations** | Organizing Tool

This resource summarizes programmatic activities that supported youth orientation to the Museum of Science and Boston University during TSRCP piloting.

*Preparing for Day One*

**Onboarding**

- Communicate with both HR departments to ensure youth have received and completed all required forms (see **Welcoming Youth to Workplaces**).
- Coordinate internally to ensure youth will have technical access to systems (e.g., user accounts, institutional email, software installations),
- Prepare physical workspaces to ensure youth have all required equipment, personal storage spaces, and project storage spaces they will need.
- Communicate with youth about where to go when they arrive on Day One, and any other expectations for their first day of work (e.g., dress code, masking policy).

*Day One*

**Orientation**

- Plan a workshop or orientation meeting agenda that will familiarize youth with organizational and program structures, expectations, with one another, and with their primary mentor(s) from each organization.
- Tour workspaces, amenities (e.g., bathrooms, first aid access), and other important locations on campus.
- If youth will participate in evaluation activities, plan for the agenda to include an introduction to the evaluation goals, as well as time to describe the associated activities, the purpose of consent/assent, and for youth to ask questions. Evaluators may find it useful to conduct data collection during the Day One Orientation (e.g. **Survey**, **Meaning Mapping Activity**).
- Orient youth to the program goals, timeline, and activities, and establish expectations for their responsibilities within the program as staff and/or representatives of both organizations.
- Familiarize youth with organizational structures and the staff that are available to them for support.
- Embed cognitive breaks in the orientation agenda to support community building (e.g., pizza break, getting to know you game, team-building activity).
- Communicate information about youth's work schedules, expectations for requesting time off, and procedures for informing mentors if they will not be able to report to work.
- Share information about the benefits that youth receive as paid staff. For example, youth employed by the Museum of Science receive reciprocal admission to many local and national cultural organizations by presenting their badge.

*Week One*

**Getting Grounded**

- Provide youth with a staff manual or similar documentation to establish shared understanding of program logistics, work-related rules, and essential procedures (e.g., safety, sanitation).
- Orient youth to the software, communication platforms, or other technical needs that they will be expected to use in the program.
- Familiarize youth with any HR or financial systems (e.g., model how to submit a timesheet; inform youth how paychecks are distributed).
- Begin foundational training in the program elements. During TSRCP we prioritized institutional training (e.g. Hazardous Materials training, Harassment policy), research ethics training (e.g. CITI↗), an Orientation to the process of conducting research in a museum setting (see **Resources**), basic customer service training, and having youth shadow experience researchers and educators.
- Invite youth to familiarize themselves with the institution, and practice wayfinding for different amenities and locations. During TSRCP piloting, youth explored museum exhibits with different visitor needs (e.g., families with young children, adult pairs) in mind, learning to direct visitors to amenities while also learning the layout of the front and back of house at the museum.

**Resources**

Researcher Orientation Guide↗ | *National Living Laboratory*
This document provides suggestions for crafting an effective orientation for personnel engaged as researchers at an informal education institution

## **TSRCP Timelines, Core Elements, and Youth Activities** | Organizing Tool

During the piloting effort, the project team worked with two different cohorts of youth. Cohort 1 (Summer 2019–Spring 2020) began the program with a summer intensive, while Cohort 2 (Fall 2021–Summer 2022) had a summer intensive at the end of their experience. Cohort 1 participated primarily in-person at the Museum of Science (ending with a brief period of remote work at the onset of the COVID-19 pandemic), while Cohort 2 participated virtually for most of the school year (ending with on-site work at the Museum of Science in the late spring and through the end of the summer).

### TSRCP Program Timelines At-a-Glance

| | | | |
|---|---|---|---|
| **Cohort 1** | Intensive summer<br>4 days/week<br>In person | School year involvement<br>1 day/week<br>In person and remote | |
| **Cohort 2** | | School year involvement<br>1 day/week<br>Remote | Intensive summer<br>4 days/week<br>In person |

The table below summarizes the experiences that youth participating in Cohort 2 engaged with, illustrating how specific programmatic activities can be mapped to the core program elements.

### Core Program Elements and Youth Activities

| Core Program Element | Youth Activities |
|---|---|
| **Engage in research practices.** | ○ CITI ethics training<br>○ pilot testing and refining research protocols (e.g., survey and interview instruments) for ongoing BU and MOS projects<br>○ data collection for BU's "Structural Mindsets" (in-person) study and the Museum's "Productive Struggle" (on-line) study<br>○ quantitative and qualitative data analysis, statistics, and data visualization |
| **Engage in science communication practices.** | ○ writing a methods description for a journal article<br>○ developing text and visuals for a conference poster<br>○ writing a handout about BU's Structural Mindsets research for museum visitors<br>○ Engaging participants in debriefing after research sessions |

| | |
|---|---|
| **Engage in science education practices.** | ○ leading hands-on interpretation activities in the Museum exhibit halls<br>○ professional development focused on child development, facilitation, and pedagogy<br>○ developing content, graphics, and prototyping museum exhibit interactives |
| **Experience mentorship from STEM professionals.** | ○ regular workshops and check-ins with primary mentors from BU and MOS<br>○ collaborative work with BU researchers and MOS researchers<br>○ working meetings with exhibit project team members (graphic and 3D designers, content and software developers, educators, evaluators)<br>○ Informal “job chats” with STEM professionals |
| **Become a member of a science community.** | ○ working in the Museum exhibit halls alongside BU researchers, and MOS researchers and educators<br>○ participating in meetings alongside MOS staff and BU students and faculty, including lab meetings and department meetings<br>○ shared projects with museum staff and university staff at various scales<br>○ sharing offices and physical workspaces with MOS staff<br>○ sharing virtual workspaces with MOS and BU staff |

## **TSRCP Program Timelines** | Organizing Tool

During TSRCP piloting, the positions that youth held were structured as year-long co-appointments with both a museum and a university. Below, we outline two overall timelines for the program that were implemented and tested during the piloting effort.

Organizations should identify a timeline that best aligns with their respective capacities and needs. Some considerations may include:

- Availability of program funding
- Access to youth populations during the summer and school year
- Mentor capacity and access to additional staff support
- Timing of research life cycles across the year
- Timing of authentic project needs
- Structures of existing youth workforce development or professional learning programs within the organization

**Example 1:** Summer intensive training, followed by academic year projects

| | **Q1 Spring** | **Q2 Summer** | **Q3 Autumn** | **Q4 Winter** | **Q5 Spring** |
|---|---|---|---|---|---|
| Collaborative Planning Period for Mentors | | | | | |
| Youth Recruitment and Hiring Period | | | | | |
| Summer Intensive Workshops and Training (4 days/week) | | | | | |
| Weekend Research and ISE Practice (1 day/week) | | | | | |

**Example 2:** Academic year training, followed by summer intensive projects

| | **Q1 Summer** | **Q2 Autumn** | **Q3 Winter** | **Q4 Spring** | **Q5 Summer** |
|---|---|---|---|---|---|
| Collaborative Planning Period for Mentors | | | | | |
| Youth Recruitment and Hiring Period | | | | | |
| *Weekend* Workshops and Training (1 day/week) | | | | | |
| Summer *Intensive* Research and ISE Practice (4 days/week) | | | | | |

## **TSRCP Pilot Program: Syllabus at-a-glance** | Organizing Tool

This document shares an example syllabus of a TSRCP cohort using a summer-intensive training schedule (see **TSRCP Program Timelines**).

### Week 1

| | |
|---|---|
| **Science Research** | ○ Complete online CITI training<br>○ Learn about Research Ethics through activities and readings<br>○ Learn how to obtain consent from parents/guardians<br>○ Practice reading and breaking down a research paper |
| **Science Communication** | ○ Complete a Living Laboratory researcher orientation (i.e., intro to conducting research with families visiting the museum)<br>○ Shadow experienced researchers on a research shift in the museum<br>○ Practice the research project study debrief with mentors |
| **Science Education** | ○ Get familiar with Museum offerings and amenities (for the public and for yourself)<br>○ Begin interpretation training, pair with an experienced educator<br>○ Learn about Museum pedagogy (e.g., Science is an Activity) |
| **Job Chat** | ○ Educational curriculum evaluator |
| **Book Club** | ○ *The Scientist in the Crib* book, Chapter 1 |
| **Equity Pauses** | ○ Introduction to Equity Pauses; Power - Reproducing vs. Transforming |

### Week 2

| | |
|---|---|
| **Science Research** | ○ Learn about study design, including identifying research questions and variables across a variety of research studies<br>○ Train with experienced researchers on a research protocol<br>○ Co-lead a research protocol during a research shift in the museum |
| **Science Communication** | ○ Reading for Research Toy #1: original paper and interpretation guide<br>○ Engage in insert development training<br>○ Draft a caregiver handout for a research study |
| **Science Education** | ○ Engage in Visitor Agendas training<br>○ Reflect on museum offerings using evaluation tools and design frameworks (e.g., EDGE, UDL)<br>○ Continue basic interpretation training |
| **Job Chat** | ○ PI from a child development lab |

| | |
|---|---|
| **Book Club** | ○ *The Scientist in the Crib book, Chapter 2* |
| **Equity Pause** | ○ Time - Short-term vs. Long-term practice |

## Week 3

| | |
|---|---|
| **Science Research** | ○ Learn to conduct a search for research literature<br>○ Find and summarize 2-3 articles related to a research project<br>○ Discuss Reproducibility and Open Science<br>○ Co-lead a research shift in the museum |
| **Science Communication** | ○ Shadow another educator presenting Research Toy #1 interpretation<br>○ Discuss and evaluate popular press articles |
| **Science Education** | ○ Engage in Understanding Audiences training<br>○ Continue initial Museum Interpretation training |
| **Job Chat** | ○ Speech Language Pathologist |
| **Book Club** | ○ "We Aren't The World" article |
| **Equity Pause** | ○ Resources - Reinforcing vs. Redistributing |

## Week 4

| | |
|---|---|
| **Science Research** | ○ Develop a mock experimental design to replicate or extend a prior research project<br>○ Begin the Research Questions and Methods module and start drafting a methods section for your research project<br>○ Use resources from the Interpreting Data module to practice computing and visualizing descriptive statistics for example data |
| **Science Communication** | ○ Engage in Poster Development training activities<br>○ Begin drafting a poster for a research project<br>○ Co-lead Research Toy #1 interpretation, for families in the museum, with an experienced educator |
| **Lab Meeting** | ○ Attend and participate in an on-campus lab meeting |
| **Job Chat** | ○ Educational curriculum evaluator |
| **Book Club** | ○ *Scienceblind* book, Chapter 1 |
| **Equity Pause** | ○ Participation - Practice done "To" vs. "With" |

## Week 5

| | |
|---|---|
| **Science Research** | ○ Begin entering and cleaning data for research project<br>○ Learn about and practice using R for data analysis<br>○ Lead a research shift in the museum |
| **Science Communication** | ○ Learn to use R and Excel to create visualizations (scatterplots, bar charts, etc.) of project data<br>○ Practice drawing conclusions from data, and extrapolating information from visual datasets<br>○ Continue drafting the Methods section for research paper<br>○ Continue developing content for a research poster<br>○ Lead Research Toy #1 interpretation with families in the museum<br>○ Readings for Research Toy #2: original article and interpretation guide |
| **Science Education** | ○ Learn to lead as a peer model for interpretation trainings<br>○ Attend design workshop to brainstorm content for interpretation development project |
| **Job Chat** | ○ Education research grad student |
| **Book Club** | ○ *Scienceblind* book, Chapter 12 |
| **Equity Pause** | ○ Centrality - Minor/Tokenistic vs. Major/Key practices |

## Week 6

| | |
|---|---|
| **Science Research** | ○ Continue Statistics module, learn to interpret basic inferential statistics<br>○ Use R to create data visualizations for research poster<br>○ Learn to interpret and create high quality captions for data visualizations<br>○ Lead Living Laboratory research shift |
| **Science Communication** | ○ Review and refine research poster<br>○ Continue developing a poster and practice presenting the poster with peers and mentors<br>○ Lead Research Toy #1 interpretation<br>○ Shadow another educator presenting Research Toy #2 interpretation with families in the museum |
| **Science Education** | ○ Act as peer role model in interpretation trainings<br>○ Read background material and the interpretation guide for a science skills interpretation<br>○ Shadow another educator presenting an interpretation focused on science skills<br>○ Attend an ISE webinar |

| | |
|---|---|
| **Job Chat** | ○ Museum evaluator |
| **Book Club** | ○ "The Lifespan of a Lie" article |
| **Equity Pause** | ○ Orientation - Individual vs. Collective |

## Week 7

| | |
|---|---|
| **Science Research** | ○ Use R to conduct inferential analyses of research project data<br>○ Lead a research shift in the museum |
| **Science Communication** | ○ Present a research poster to professional audiences (e.g., lab members, Museum colleagues)<br>○ Lead the presentation of Research Toy #1 interpretation with families in the museum<br>○ Lead the presentation of Research Toy #2 interpretation with families in the museum |
| **Science Education** | ○ Act as peer model in an interpretation training<br>○ Co-lead an interpretation focused on science process skills<br>○ Curate and document prototype materials for interpretation development project |
| **Job Chat** | ○ Neuroscience postdoc |
| **Book Club** | ○ *Einstein Never Used Flashcards* book, Chapter 2 |
| **Equity Pause** | ○ Approach – Deficit vs. Asset-based |
| **Career Panel** | ○ Attend an undergraduate panel about STEM experiences in college |
| **Lab Meeting** | ○ Meet with PI and other lab members to discuss academic year research project |

## Week 8

| | |
|---|---|
| **Science Research** | ○ Begin preparation of study materials (e.g., insert, stimuli, instruments) for academic year research project<br>○ Contribute to the submission of a study for visitor experience approval by museum staff<br>○ Draft a plan for piloting the methods for the research project to be conducted during the academic year |

| | |
|---|---|
| **Science Communication** | ○ Present a research poster to public audiences (e.g., family/friends, Museum visitors)<br>○ Lead research toy interpretations with families in the museum<br>○ Draft a caregiver handout for the research study to be conducted during the academic year |
| **Science Education** | ○ Lead the presentation of an interpretation focused on science process skills for families in the museum<br>○ Attend a department meeting with museum staff to learn about educational efforts you will support during the academic year<br>○ Meet with education team to pitch interpretation project plan, and prepare to integrate feedback |
| **Job Chat** | ○ Museum content developer |
| **Book Club** | ○ *Einstein Never Used Flashcards* book, Chapter 3 |
| **Equity Pause** | ○ Interests - Dominant vs. Underserved |
| **Career Development** | ○ Incorporate summer experiences (training and practical work) into your resume<br>○ Write a mock cover letter for research assistant position |

## **Youth Projects: Examples from TSCRP Piloting** | Organizing Tool

This resource broadly outlines processes mentors used to support five different types of youth-driven projects, using examples from TSRCP piloting.

For many fields of research, the duration of a study's lifecycle from conception to publication is longer than that of a youth employment program. During TSRCP piloting, we found that youth saw value in contributing to multiple projects that were at different phases, even if they were not able to see one project through from beginning to end. We use five case studies to highlight the roles youth played in different phases of the research and science communication process and include information about the mentorship needed to support projects of this nature.

### 01 | Study Replication and Extension – "Stickers"

In this project, youth supported data collection and early analysis on a replication and study extension of *Give as I give: Adult influence on children's giving in two cultures* (see Resources). Work included leading data collection with Museum visitors, writing a caregiver handout for the study that summarizes the research questions and methods for public audiences, contributing to initial data analysis, and developing a study poster that was shared with lab members and Museum visitors.

To prepare youth to successfully contribute to the study replication and extension, mentors:

- Oriented youth as researchers in the museum setting (in the Living Laboratory↗ model)
- Documented youth completion of CITI training and added youth to the study's IRB
- Trained youth on the study protocol and modeled data collection practices
- Shadowed and approved youth to lead data collection
- Provided youth with best practices and templates for writing caregiver handouts
- Shared feedback, questions, and edits on drafts of caregiver handouts
- Trained youth on data analysis methods
- Oversaw generation of data visualizations by youth
- Led workshop activities on best practices for poster development
- Reviewed and supported refinement of poster formatting and language
- Coordinated a poster review session with University and Museum colleagues

Products from this work can be found at: How does seeing someone share change children's giving?↗

## 02 | Study Design and Pre-Registration - "Structural Mindsets"

In this project, youth collaborated with research mentors to develop and pilot a methodology for a new child development study exploring the impact of a "structural mindset" on motivation. Work included reading research articles to build familiarity with existing constructs and study methodologies (fixed mindset, growth mindset, structural mindset) and collaborating with research mentors to integrate validated measures into a new protocol. Youth also piloted methods and met with research mentors to debrief and iterate on the protocol and drafted a methods section for a study pre-registration on the Open Science Framework↗.

To prepare youth to successfully contribute to the study design and pre-registration, mentors:

- Oriented youth as researchers in the museum setting (in the Living Laboratory↗ model)
- Documented youth completion of CITI training and added youth to the study's IRB
- Trained youth to read research articles
- Introduced youth to existing paradigms and collaboratively reflected with youth on their appropriateness and integration
- Oversaw and provided feedback on youth protocol development and iteration
- Trained youth as data collectors and co-piloted draft protocols
- Coordinated meetings with youth and project stakeholders to describe successes, resolve challenges, and identify next steps
- Led a series of Methods writing workshops
- Supported youth to refine their content for study pre-registration on OSF
- Documented study development processes and created training materials for full-scale data collection

Products from this work can be found at: How does a "structural mindset" impact children's motivation?↗

## 03 | Systematic Literature Review - "Imagination in ISE"

In this project, youth contributed to a comprehensive review of literature on imagination in STEM and ISE (informal STEM education). Work included reviewing articles for inclusion criteria, pulling definitions of imagination and associated terms into a shared spreadsheet, and contributing to an annotated bibliography.

To prepare youth to successfully contribute to a systematic literature review, mentors:

- Trained youth to find and read research articles
- Provided context for the goals of the literature review, and trained on project specific processes modeled after *7 Steps to a Comprehensive Literature Review* (see **Resources**)
- Reviewed existing criteria for inclusion and provided a spreadsheet framework for youth to document their work
- Onboarded youth to using Mendeley, a research literature and reference management software
- Invited youth to regular team meetings to collaboratively problem solve, share updates, and discuss emergent themes
- Shared best practices for summarizing research articles, and provided constructive feedback and questions on youth's written drafts

Products from this work can be found at: Imagination in STEM Education and Practice: Comprehensive Literature Review (Executive Summary)↗

## 04 | Data Collection, Analysis, and Reporting - "Productive Struggle"

In this project, youth led virtual data collection, analysis, and reporting for a research study comparing teen engagement in a physical and digital "Mystery Skulls" exhibit, designed to elicit productive struggle (see **Resources**). Work included meeting with participants online to conduct an observation and interview protocol, entering data, and analyzing and visualizing descriptive statistics for both study conditions. Youth also wrote and submitted a poster proposal to the ASTC 2021 Annual Conference, which was accepted and subsequently presented by youth.

To prepare youth to successfully contribute to the data collection, analysis, and reporting for this study, mentors:

- Documented youth completion of CITI training and added youth to the study's IRB
- Trained youth on the study protocol and modeled data collection practices
- Shadowed and approved youth to lead data collection
- Coordinated data collection sessions between youth and participants
- Met regularly with youth to review updates and discuss any troubleshooting needs
- Trained youth on relevant statistical analyses
- Created table and graph templates for youth to document data analyses and interpretation
- Co-authored a conference poster proposal with youth, while mentoring youth in writing a proposal
- Led workshop activities on best practices for poster development
- Oversaw youth poster development and shared feedback and edits on formatting and language
- Coordinated youth attendance at a virtual conference

Products from this work can be found at: 2021 Poster: Comparing Engagement, Learning, and Value in Physical and Virtual Exhibits↗

## 05 | Activity Development and Prototyping - "AI is All Around Us"

In this project, youth applied their science research and education training to contribute to the development of a virtual activity about the many ways AI intersects with our everyday experiences. Work included participating in a design workshop to identify potential vignettes, designing and leading a front-end evaluation to understand museum visitors' perceptions of AI technologies, and developing a paper prototype (an early draft of an exhibit) of an "AI scavenger hunt" activity in the context of a college dorm room.

To prepare youth to successfully contribute to the development and prototyping of the AI virtual activity, mentors:

- Trained youth to find and read research articles
- Coordinated and led a design workshop to support youth brainstorming
- Defined and communicated learning goals for the activity, along with development timelines, to youth
- Oriented youth to Team-Based Inquiry methodology (see **Resources**)
- Oversaw and provided feedback on youth development of front-end evaluation study methods
- Modeled data collection techniques with youth
- Trained youth to use Excel to organize, enter, clean, manipulate, and visualize data
- Coordinated meetings between youth and project stakeholders

Products from this work can be found at: AI is All Around Us↗.

**Resources**

7 Steps to a Comprehensive Literature Review↗ **|** *Onwuegbuzie & Frels*
This book is a practical guide for researchers engaged in a systematic literature review.

Designing for Productive Struggle: A Research and Development Guide to Creating Exhibits that are Both Challenging and Rewarding↗ (pg. 32-46) | *Museum of Science, Boston*
This guide offers exhibit design strategies that support learners to feel both challenged and satisfied by an experience.

Give as I give: Adult influence on children's giving in two cultures↗ | *Blake, Corbit, Callaghan, & Warneken*
This study explores the role of an adult modeling generous or selfish sharing on children's own sharing behavior.

Team-Based Inquiry Guide↗ | *NISE Network*
This guide provides a practical approach for introducing and training education practitioners in the process of evaluation.

## **Considerations for Mentors** | Organizing Tool

This resource outlines specific questions to help guide mentor decision-making about programmatic implementation.

### Establishing Format

- What program timeline and duration will best support authentic youth engagement? **TSRCP Program Timelines** highlights two different structures (summer-first and summer-last) for a year-long program; mentors should consider what model will best suit their needs.

- To what extent will each institution lead youth recruitment, hiring, and onboarding processes? During TSRCP piloting, the Museum of Science leveraged existing connections with high schools and youth-serving community organizations to recruit candidates for each cohort.

- Where will youth physically be located for programmatic work? During TSRCP piloting, youth work was primarily situated at the Museum of Science in order to leverage the Living Laboratory model. Some program elements took place remotely or on the Boston University campus.

- How many hours per week will staff from each institution commit to mentorship and other project needs? While this may fluctuate week to week, it is important to build a shared understanding of each institution's capacity in order to appropriately scale activities and project work.

- How will mentors communicate needs with one another?
  Setting up regular mentor check-ins with pre-set but flexible agendas supports ongoing communication about program needs, updates, and logistics.

### Setting Programmatic Expectations

- Which modules will be led by the research mentors)? Which modules will be led by the education or science communication mentor(s)? Mentors may find that there is overlapping expertise across several modules; exploring the unique perspectives of each institution can be a rich learning opportunity for youth.

- What is the frequency of workshops, trainings, and other learning experiences? During TSRCP piloting, mentors identified specific "workshop days", "research days", and "project workdays" to coordinate their own and youth's time effectively.

- What project(s) will youth contribute to? What team-based and institutional support is available? During TSRCP piloting, youth engaged in a number of research, science communication, and science education projects that involved support from staff in addition to the primary mentors (e.g., RAs modeling research protocols, content developers offering activity development feedback). Consider how to balance project timelines and support needs across the duration of the program.

- What product(s) are expected from youth projects? Set specific goals and identify the resources needed as you define the scope, pacing, and duration of a project. During TSRCP piloting, youth expressed interest in developing their own research question and study design, but mentors found that the open-ended nature of that work made it challenging to set timelines that would result in a meaningful product. Mentors re-scoped study design contributions (piloting and iteration of methods), allowing youth to work toward a satisfying product (study registration and poster).

## Supporting Youth

- How will programmatic expectations be communicated with youth? Consider what specific values, requirements, or rules each organization may bring to the table, and ensure mentors and supervisors are consistently and clearly communicating with youth.

- What organizational and communication platforms will youth need to use? During TSRCP piloting, mentors found that maintaining a universal communication plan for program needs (versus different platforms and/or approaches for each organization) was most effective for youth.

- How will mentors track youth professional growth? Make a plan for how goals will be set, how training will be tracked, and how competencies will be assessed, and how feedback will be documented and communicated. During TSRCP piloting, mentors held regular meetings with the entire youth cohort, as well as one-on-one meetings with youth (see **Youth Check In Template**) to maintain ongoing dialogue about successes, challenges, and growth over time.

## **Youth Check in Template** | Organizing Tool

Attendees: _____ Date: _____

| | |
|---|---|
| **Logistical Notes**<br><br>Are there any schedule updates? What are your project needs and current priorities? | |
| **Successes**<br><br>What is something that is going really well / that's been really engaging / that you're really proud of? | |
| **Challenges**<br><br>What's something that has been more of a challenge / that feels less engaging / that you want more support on? | |
| **Goals**<br><br>What's a skill or practice you'd like to work on developing?<br><br>What strategies or supports do you need to be able to work toward that goal? | |

## **Community Building Activities** | Module

This module offers strategies for building youth participation in different communities.

### Goal #1 Develop a sense of community among youth participants.

- Make use of icebreaker questions and teambuilding games to help youth get to know other members of their cohort and build interpersonal relationships with peers.
- Create opportunities for youth to share their personal interests or skills with one another. For example, if a youth has a particular interest in a topic, invite them to lead a discussion about a related article. If a youth has graphic design skills, invite them to lead the design portion of a project.
- Build space for youth to connect their own lived experiences, perspectives, and identities to program elements. Content-driven conversations (see **Book Club Overview**) are a great opportunity for youth to bring themselves to the table.
- Create physical spaces that support a sense of youth ownership. During TSRCP piloting, youth shared an office space with desks that they were able to decorate in a way that represented them, store and show off products of their work, and use as a casual convening space.

### Goal #2 Connect youth with professional STEM communities.

- Invite STEM experts to engage directly with youth. There are a number of strategies for coordinating conversations with local experts (see **Community Connection Chats**) that are supportive of youth engagement with STEM professionals.
- Bring youth to the physical or digital spaces where the community convenes. For example, during TSRCP piloting, mentors connected youth to physical spaces through field trips to Boston University, and to digital spaces by adding them to relevant Museum community conversations on Microsoft Teams. When possible, youth also attended all-staff, divisional or department meetings with Museum staff, as well as lab meetings with BU staff.
- Create or find opportunities for youth to be viewed by others as STEM experts. These opportunities may include submitting a proposal to a conference (presenting at a virtual conference was very impactful for youth during TSRCP piloting); hosting a mini poster session for peers, colleagues, or family members; or directly engaging the public in conversations about their work.
- Consider leveraging physical or logistical components of “belonging” to a professional network. For example, during TSRCP piloting, youth wore red lab coats when serving as informal science educators and Boston University (BU) t-shirts while conducting BU research with families; youth also received both Museum of Science and BU credentials for accessing technical systems of both organizations.

## **Book Club Overview** | Discussion Guide

This guide provides suggestions for structuring a STEM Book Club with high school students.

Engaging in a regularly occurring “book club” discussion group supports youth to develop STEM content knowledge and provides exposure to science communication through popular press. During TSRCP piloting, facilitating discussions around topics of particular interest and relevance to the specific cohort of students participating provided rich identity and community-building opportunities.

**Structuring a Book Club**

Identify content and discussion topics that align with other programmatic elements and reflect youth’s interests. Notice new interests that emerge or how interests evolve for youth over time and adjust content to reflect these changes. During TSRCP piloting, youth were primarily engaged with child development research content through Living Laboratory, so the mentors’ selection of books, articles, and other media reflect that work.

Attend to fluctuations in youth energy levels across their schedule and select appropriate Book Club times to support their needs. In TSRCP, mentors held Book Club at the end of training-heavy days, when youth were ready for lower-energy, more reflective engagement.

Set expectations for asynchronous youth engagement with Book Club resources. Consider how much youth participants will be expected to read in between meetings or other responsibilities and ensure enough time is set aside to meet that need. Identify the priority level of book club reading in relation to other projects and ensure this is communicated with youth.

Consider spaces that are conducive to focused reading time. While some youth may find their workspace effective for sustained attention to book club media, other youth may be better served by alternate environments (e.g., space outdoors, quiet room, cozy seating).

**Discussion Strategies**

Create an open and trusting dialogue by establishing "ground rules" for conversation. In TSRCP piloting, mentors used the *NISENet Forums Manual* as a guiding document for facilitation (see **Resources**, below).

Brainstorm some questions you can use to kickstart the conversation and support discussion. Examples include:

- What was something new you learned?
- Did you have a favorite part of the reading? A least favorite part?
- Do you see any connections between this content and your own life?
- What was something you thought the author communicated especially well?

Encourage youth to brainstorm 1-3 questions or reflections they'd like to share in advance of the Book Club meeting. Youth may find the **Discussing a Research Paper** tool or the *QALMRI Method* (see **Resources**, below*)* useful for strategically identifying discussion topics.

Pair the Book Club conversation with a related activity (e.g. article about the Stanford Prison Experiment and Research Ethics activity), and invite youth to make connections between the reading and their practice.

**Resources**

NISENet Forums Manual↗ (pg 20 - 23) **|** *NISENet*
This document offers suggestions for establishing effective small group dialogue.

QALMRI Method (Question Alternatives, Logic, Methods, Results, and Inferences)↗ | *Brosowsky, Parshina, Locicero & Crump*
This article introduces the QALMRI method for reading and interpreting empirical research articles.

## **Book Club Resources** | Resource List

This resource list suggests books, pop-press articles, and other media for use in Book Club discussions.

**Books**

Einstein Never Used Flashcards: How Our Children *Really* Learn—And Why they Need To Play More and Memorize Less↗ | *Kathy Hirsch-Pasek, Roberta Golinkoff, Diane Eyer*
This book connects early childhood education to critical stages in child development, and offers resources for practicing and noticing developmental skills in young children.

Mind in the Making: The Seven Essential Life Skills Every Child Needs↗ | *Ellen Galinsky*
This book explores executive functions from a developmental perspective, and how they are applied across the lifespan.

Scienceblind: Why Our Intuitive Theories About the World are So Often Wrong↗ | *Andrew Shtulman*
This book provides a review of research on how science theories and epistemologies develop, and the implications for science education.

The Scientist in the Crib: What Early Learning Tells Us About The Mind↗ | *Alison Gopnik, Andrew Meltzoff, Patricia Kuhl*
This book unpacks infant development, and reviews research on how babies' brains develop over time.

**Articles**

Researchers Show Parachutes Don't Work, But There's A Catch↗ | *Richard Harris, NPR*
This tongue-in-cheek article reviews a satirical experiment designed to highlight the challenges in creating appropriate and transparent methodology in empirical research.

The Lifespan of a Lie↗ | *Ben Blum, Medium*
This article offers a critique of the Stanford Prison Experiment and discusses the implications of that research on policy and culture.

The "marshmallow test" said patience was a key to success. A new replication tells us s'more.↗ | *Brian Resnick, Vox*
This article reviews the cultural implications of the Delayed Gratification "Marshmallow" Task and discusses more recent research challenging the original findings.

We Aren't the World↗ | *Ethan Watters, Pacific Standard Magazine*
This article highlights the importance of engaging in cross cultural research, and de-emphasizing research findings primarily found from WEIRD populations as the "norm".

What psychology's crisis means for the future of science↗ | *Brian Resnick, Vox*
This article discusses the reproducibility crisis in psychology and its implications for future research efforts.

**Videos**

Delayed Gratification (Marshmallow Task)↗ | *Igniter Media*

Still Face Experiment↗ | *UMass Boston*

Infant Moral Judgements↗ | *New York Times*

Visual Cliff↗ | *SciFri*

Infant Motor Learning↗ | *NYU Action Lab*

Infant Emotion Recognition and Response↗ | *Wall Street Journal*

Infant Self Awareness (Shopping Cart Test)↗ | *David Martin*

Infant Self Awareness (Scale Error)↗ | *David Martin*

Inhibitory Control (Day/Night task)↗ | *FWIChannel*

Theory of Mind (Broccoli/Crackers Task)↗ | *Irnweb*

Theory of Mind (False Belief Task)↗ | *007IceWeasel*

Piaget's Conservation Tasks↗ | *Munakatay*

Give-N Task↗ | *Lookit at MIT*

Brazelton Neonatal Assessment↗ | *FWIChannel*

Self Regulation with Cookie Monster↗ | *NPR Podcasts*

## **Community Connection Chats** | Discussion Guide

This guide outlines approaches to connecting youth with STEM professionals in informal settings.

Community Connection Chats are a mechanism for engaging youth with members of professional networks that they are interested in. A sense of belonging in a science community is a key element of STEM identity explored in this project; inviting members of STEM networks to connect with youth is one approach to building communities.

**Format Options**

Job Chat: In these chats, a STEM professional meets with a group of youth to have an informal conversation about their identity as a scientist, school and career pathways, and current work.

College or Career Panel: In these chats, a curated selection of speakers discusses a particular area of interest (e.g., “Undergraduate Life”, “Careers in Neuroscience”, or “Finding Gap Year Experiences”) with a group of youth.

Mini-lab meeting: In these chats, a STEM expert hosts a discussion about a topic they choose. Topics may include a critical review of a recently published paper in the speaker’s field, a debate about a current STEM challenge (e.g., replication), or an introduction to a skill or area of interest (e.g., inferential statistics). This format can involve multiple members of the speaker’s team who are at multiple stages of career.

**Connecting with STEM Professionals**

Invite speakers/discussants that are able to connect back to the projects that youth are engaged in - for example, if youth are learning about child development research, invite a researcher who studies children’s causal reasoning!

Utilize mentors’ personal and professional networks to recruit speakers/ discussants; these could be colleagues, grad students, undergrads, etc.

Leverage opportunities to amplify early-career and diverse voices. Creating space for youth to see STEM professionals that are like them (e.g., a near-peer undergrad) is supportive of identity development and helps build community relationships.

Set expectations for speaker/discussant prep. Youth generally find informal conversation and active participation most engaging, so it may be useful to constrain any presentations or lectures to a limited portion of the chat.

**Preparing for Community Connection Chats**

Ask youth to brainstorm some questions for the guest speaker/discussant in advance of meeting. During TSRCP piloting, youth used Padlet↗, an online collaboration platform, to organize their questions and reflections in advance of meetings.

Engage youth in activities that help them prepare for the chat:

- For Job Chats, provide short bios for upcoming guest speakers/discussants (and share a link to their website, when possible). Encourage youth to learn a little about the speaker in advance.
- For College and Career Panel chats, invite youth to reflect together on their own values, identity, or future plans. Encourage them to construct panel questions or discussion topics that align with their experiences and needs.
- For Mini-Lab Meetings, make time for youth to read and reflect on any materials provided by the guest speaker/discussant. If youth are new to a lab meeting format, it may be useful to create a safe space to "dry-run" a brief preview of the discussion to ensure they are feeling confident and prepared.

**Considerations for Discussion**

Make use of icebreaker questions to kick off conversation between speakers/discussants and youth.

Prepare some questions in advance that open the floor for questions from and discussion with youth. Some examples include:

- How did you end up in the field you're currently working in?
- What accomplishment are you most proud of?
- What were your future plans when you were starting college, and how does that compare to your experiences now?
- What were you most surprised by when you started working in this field?
- What kinds of skills or characteristics make someone successful in your field?

Bring snacks or fidgets to meetings with guest speakers/discussants. Being "engaged" may look different across individuals; providing options for productively maintaining attention helps neurodiverse youth feel safe and helps ensure that guests feel their time is valued.

When permitted, share the speaker/discussant's contact information with youth, so they have an opportunity to follow up on and maintain their connection after the meeting.

# 02 | Science Research

## **Science Research – An Introduction** | Module

This module introduces youth to the nature of science and the processes involved in peer-reviewed science research.

**Goal #1** **Clarify existing youth conceptions about the nature of science.**

- Encourage youth to reflect on what science means to them. What words come to mind when they think of science? What words come to mind when they think of scientists? How would they define "science" versus "research"? During TSRCP piloting, the **Meaning Mapping Activity** was one approach used to foster this dialogue.
- Revisit youths' science conceptions over time. As youth engage in program modules and activities, encourage them to reflect on whether any of their experiences have either changed or affirmed their conceptions of science.
- Discuss defining philosophies and frameworks about science, e.g., epistemologies (How do we know what we know?), empirical vs. non-empirical knowledge (What does it mean to be objective?), inquiry (What does practicing science look like?).

**Goal #2** **Deepen youths' mental models of the scientific process.**

- Invite youth to describe their conceptions of the research process. Organize their ideas into sequential phases and refine or add to build a complete picture of the research lifecycle (see ***Appendix*****:** "Research Phases Infographic", for an example used during TSRCP piloting). Invite youth to share any previous experiences they may have had contributing to phases of this process (e.g., searching for existing research on a topic, repeating trials of an experiment).
- Review the research lifecycle model regularly with youth, particularly as they undertake project work in new phases of the research process. Discuss how specific elements of a research phase tie back to the overarching goal or question.

- Invite youth to share what parts of the research process they're most excited to learn about and contribute to.
- Investigate empirical research articles as artifacts of the research process. Engage youth in exploration of a study's research phases as documented in its publication(s). Where is the literature review documented? Sample selection and justification? Further inquiry?
- Train youth as research assistants engaged in the Living Laboratory model. Describing studies with the public provides youth with plentiful opportunities to practice framing the scientific method within the context of their research.

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**Goal #3** **Introduce youth to a range of social science fields and disciplines.**

- Compare and contrast "hard" sciences vs. "soft" sciences, and "western" vs. "indigenous" ways of knowing. Encourage youth to reflect on how different scientific fields/disciplines are typically conceptualized and valued - by the public, by educators, and by other scientists.
- Coordinate **Community Connection Chats** with STEM professionals representing a range of social science disciplines.
- Invite youth to attend and participate in lab meetings, workshops, webinars, or other professional convenings where they can learn alongside other scientists and engage in meaningful dialogue about current issues in STEM.
- Engage youth in a regular book club (see **Book Club Overview**) to read and discuss books, articles, and other media about scientific content. Encourage youth to select media that aligns with their scientific interests, and to compare and contrast content across disciplines (e.g., how is a neuroscience article vs. an article about evolution presented?)

## **Research Platforms** | Resource List

This document offers an annotated list of platforms used to support research projects.

| | |
|---|---|
| **Google Scholar** | Google Scholar is a search engine that allows users to find and access scholarly literature. Whenever available, Google Scholar also provides the full text PDF of research articles. |
| **EBSCOHost** | EBSCOHost is a research publication platform that hosts a number of databases containing peer reviewed articles and other research artifacts. |
| **Mendeley** | Mendeley is a reference management software, which allows users to download research articles and other reference material from the internet, and sync files in a shared workspace. Mendeley also allows users to annotate documents, create topical tags, and automate citation generation. |
| **Open Science Framework** | The Open Science Framework is a project management platform that allows users to collaboratively plan and document their research. OSF's Pre-Registration system invites users to formally and publicly document their study plans and decisions, which allows researchers to transparently share the lifecycle of their study and mitigate bias. |
| **R and R Studio** | R is a statistical programming language that supports analysis and visualization of research data. R Studio is a free, open-source software that allows users to work with the R programming language in a user-friendly environment. A number of downloadable packages are available to install. |
| **R Swirl** | Swirl is a downloadable add-on package for R that offers users an orientation and basic training on R in an interactive and game-like format. |
| **R Markdown** | Markdown is a downloadable add-on package for R that transforms the R Studio environment into a "lab notebook," which allows users to create, annotate, and execute code; document products and visualizations of data; and generate research reports, within a single file. |
| **R ggplot2** | ggplot2 is a downloadable add-on package for R that adds functionality and simplifies the process of creating data visualizations. |

## **Elements of a Research Paper** | Module

This module supports youth to find, read, and think critically about academic research publications.

**Goal #1** **Build youth capacity to make meaning of academic research articles and data.**

- Break down an exemplar empirical research article into its basic elements, discuss the purpose of each element, and invite youth to draw connections back to the scientific method.
- Share graphic organizers or other tools to support effective notetaking and comprehension. During TSRCP piloting, we used *Reading Researcher Papers - An Educator's Guide*, an organizer tool developed as part of the National Living Laboratory initiative (see **Resources**, below)
- Pair study articles with demonstrations of the research methods. During TSRCP prototyping, mentors used *Living Laboratory Research Toys* (see **Resources**, below) to roleplay the experience of engaging directly in the study and support other meaning-making opportunities.
- Invite individual youth (or pairs) to take a deep dive into the content of a publication they are personally interested in, and then lead a group discussion or book club session with their peers

**Goal #2** **Support youth to engage in critical reflection and discussion around current research topics.**

- Model strategies for unpacking and critically discussing research publications. During TSRCP piloting, the **Discussing a Research Paper** tool and the *QALMRI Method* (see **Resources**, below) were used as tools to support youth in developing questions and conversation starters.
- Host "mini-lab meetings" with study authors or lab PIs (see **Community Connection Chats**). Select an article to pre-read or invite the author to suggest a topic and encourage youth to discuss questions and reflections together. During TSRCP piloting, youth used Padlet↗, an online collaboration platform, to organize their reflections in advance of meetings.

**Goal #3**

**Support youth self-efficacy in navigating research platforms and finding publications.**

- Structure sharing and organization of research readings within reference management software such as Mendeley↗. During TSRCP piloting, use of these platforms was embedded into everyday research tasks so that as youth grew their familiarity and self-efficacy in using them; they were then better able to navigate their own project management needs.
- Offer opportunities to playfully explore research publication search engines and databases, such as Google Scholar↗ or EBSCOHost ↗. In TSRCP, youth played a "Google Scholar Scavenger Hunt" to build their skills in identifying effective keywords, utilizing Boolean operators, and general system navigation.

**Resources**

Reading Research Papers - An Educator's Guide↗ | *National Living Laboratory*
This document is an organizing and notetaking tool for reading research papers.

Living Laboratory Research Toys↗ (see "Hands-On Activities") | *National Living Laboratory*
This website provides resources for interpreting and modeling classic child development research studies.

QALMRI Method (Question Alternatives, Logic, Methods, Results, and Inferences)↗ | *Brosowsky, Parshina, Locicero & Crump*
This article provides an introduction to the QALMRI method for reading and interpreting empirical research articles.

## **Discussing a Research Paper** | Discussion Guide

This document provides a framework to support youth in developing insightful "Discussion Points" when reading research literature.

There are many good methods for developing thoughts and ideas related to books, journal articles, and other media. This guide focuses on one method to support youth in generating ideas to bring to a discussion. "Discussion Points" are questions or statements that provoke additional thought or deeper understanding when discussing a topic with others.

**Crafting a strong discussion point**

Discussion Points use evidence from a reading to make connections. Connections might be to one's own knowledge or expertise, to another part of the same reading, or to a different resource.

Support youth to develop strong Discussion Points by offering suggestions:

- Summarize the author's main points and apply your own interpretation, including:
  - Considering potential applications to research, practice, or education
  - Suggesting alternate hypotheses or conclusions
  - Applying concepts to existing practice (e.g., working with families or children)
- Make observations about intersections between two topics in the reading, including:
  - Comparing and contrasting particular concepts
  - Discussing how particular concepts relate to one another and why that matters
- Theorize possible connections between the reading and other concepts, including:
  - Interpreting concepts through the lens of particular theories or perspectives
  - Identifying alternate methodologies or explanations
- Envision avenues for future investigation, including:
  - Applying concepts to relevant current events/societal issues
  - Suggesting new research studies to expand our understanding of the concept
  - Highlighting relevant topics that were not addressed, and why they are important

**Scaffolding discussion points**

As youth build their confidence engaging in dialogue about research literature, make use of probes to support them in further developing or refining their discussion point. You might invite youth to:

- Recall or summarize findings, by asking “Do you see any connections between that finding and your own experiences?”
- Share a subjective opinion, by asking “What part of the reading made you think that?”
- Critique the methodology or findings, by asking “What alternative would you suggest? Why?”

**Additional considerations**

As youth reflect on potential Discussion Points for a reading, encourage them to keep in mind:

- Discussion Points are conversation openers: a Discussion Point does not have to have an immediate answer or be “solved”, it is just calling attention to something that is worth thinking about.
- Discussion Points are specific and use evidence: it is important to provide enough information and evidence to help conversation partners confidently engage in a productive discussion.
- Discussion Points rely on critical thinking: Discussion Points start with the assumption that the reading has important information to share, but also question *how* it is important or relevant.

## **Research Ethics** | Module

This module provides youth with theoretical background and practical training in research ethics.

**Goal #1** **Train youth to engage ethically in research processes.**

- Offer certification in human subjects research compliance through a nationally-recognized research ethics training program (e.g., *CITI Program* or *Human Research Protection Training,* see **Resources**) or other human subjects training, as required by your institution.
- Provide youth with opportunities to shadow experienced researchers across all stages of the research process, to model best practices in research ethics.
- Build research transparency by making use of open science platforms to document youth projects (see **Reproducibility and Open Science**).
- Invite youth to observe ethical research practices through the lens of an IRB submission process, e.g., through reading and discussing an existing IRB protocol, contributing to parts of an IRB application, or discussing IRB submission processes with senior members of a research team.

**Goal #2** **Provide opportunities to discuss and reflect on the history of ethics in human subjects research.**

- Select articles or other media for youth to engage with that highlight examples of research ethics violations (see **Ethics Dialogue - Milgram Obedience Study** and **Ethics Dialogue - Secret Twins Study** for examples). Encourage youth to reflect on and discuss the content through the lens of their own research ethics training.
- Ask youth to reflect on the impact unethical research practices have on science's trustworthiness. How do ethics violations threaten the integrity of research findings? How do ethics violations impact scientists' relationships with public audiences? What long term consequences might emerge from ethical violations?

- Using the "Research Phases Infographic" (see ***Appendix***), encourage youth to reflect on where research ethics may be integrated into the process. What phases require ethical consideration? What does it look like to engage ethically at each phase? Challenge youth to find news, review, or popular press articles that report on examples of ethical failures at each stage in the research process.

**Goal #3**

**Support youth to reflect on Questionable Research Practices (QRPs) and potential solutions.**

- Introduce the concept of QRPs and review common QRPs scientists engage in. During TSRCP piloting, mentors and youth read and discussed articles found in **Research Ethics Resources**.
- Engage youth in dialogue about the impact of QRPs and other ethical violations on research reproducibility (see **Reproducibility and Open Science**).
- Invite youth to brainstorm different solutions to problems that arise from QRPs and research ethics violations. How can we discourage researchers from using QRPs? What incentives could exist (or already exist) to discourage ethical violations?

**Resources**

CITI Program↗
The CITI (Collaborative Institutional Training Initiative) Program offers educational materials and training in research ethics and compliance. Many institutions use CITI Training certification as a prerequisite for engaging in human-subjects research.

Human Research Protection Training↗
Human research Protection Training is a series of free online courses offered by the U.S. Department of Health and Human Services, which offers training and certification in ethical human subjects research.

## **Ethics Dialogue – Milgram Obedience Study** | Handout

This document shares conversation starters about research ethics through the lens of the Milgram Obedience Study.

### Study Overview:

**Premise**

The major research question Stanley Milgram wanted to answer was where people stand when obedience to authority conflicts with personal morality. Milgram asked "Could it be that Eichmann and his million accomplices in the Holocaust were just following orders? Could we call them all accomplices?" (Milgram, 1974)

**Procedure**

Volunteer research participants were invited to Milgram's lab space in Yale University. Subjects were men between 20 and 50 years old with a range of occupations. Subjects were compensated $4.50 for participation.

Upon entering the lab, subjects met an experimenter and another "participant" (who was actually a confederate in the study). The experimenter disclosed that the purpose of the study was to investigate learning, through use of shock punishment. The subject and confederate drew straws to determine who would be the "teacher" and who would be the "learner". It was rigged such that the subject would always be the "teacher". The "teacher" and "learner" were then shown to separate rooms. The experimenter explained that the "teacher" would read off word-pairs to the "learner" and then test him by cuing one of the words and asking the "learner" to provide the pair. The experimenter instructed the "teacher" to administer an electric shock for each mistake the "learner" makes. There were 30 shock levels and ranged from 15 volts to 450 volts, with corresponding warnings (e.g., "Slight shock", "Danger-Severe Shock").

The "learner" purposely gave incorrect responses and expressed dismay and pain at the shocks. If the "teacher" refused or hesitated to shock the "learner", the experimenter gave a series of prods: "Please continue." "The experiment requires you to continue." "It is absolutely essential that you continue." "You have no other choice but to continue." The experiment ends if "teachers" refuse to administer a shock or if the largest voltage shock is administered (450 volts). Milgram debriefed participants at the end of the study and followed up with participants after a period of time, to disclose the true nature of his study and assure participants that their behavior was common.

**Results**

Of the 40 participants, 65% continued to the highest level of shocks. All participants continued to 300 volts. Milgram ran a series of studies with slight variations (e.g., changing the room, adding another teacher, having the experimenter dress without a lab coat, etc.) and found small variations could decrease or increase obedience.

**Discussion Questions**

- How was deception used in this study? Was deception necessary? Could this study be accomplished without deception? How?
- Did the Milgram study consider protection of participants? If not, what could've been done differently?
- Discuss whether Milgram provided participants the right to withdraw from the study. What are arguments that he did and what are some arguments that he did not?
- Should deception be used in studies? Under what conditions is it okay to use deception? Many child development studies use forms of deception with children, what can researchers do to ensure their safety?

**Resources**

Fake TV Game Show 'Tortures' Man, Shocks France↗ |
*Eleanor Beardsley, All Things Considered*
This radio show summarizes a replication of the Milgram Obedience Study that took place in a fake reality show setting.

How Would People Behave in Milgram's Experiment Today?↗ |
*John Greenwood, Behavioral Scientist*
This article describes the implications of the Milgram Obedience Study and reviews subsequent replications.

## **Ethics Dialogue – Secret Twins Study** | Handout

This document shares conversation starters about research ethics through the lens of the Secret Twins Study.

### Study Overview:

**Premise**

One common approach to studying the developmental effects of genetics and the environment (e.g., nature vs nurture) is to study twins. Fraternal (non-identical twins) have 50% shared DNA, the same as siblings. Identical twins have 100% shared DNA. Thus, studying elements through twins allows researchers to determine how much an outcome is determined by the environment or genetics. Beginning in the early 1960's, Dr. Peter Neubauer and Dr. Viola Bernard sought to use this paradigm to study mental health, personality, aggression, and many other outcomes.

**Procedure**

Neubauer and Bernard, working with local adoption services, split up at least 5 pairs of identical twins and 1 pair of identical triplets during the adoption process. He was able to assign the children to different types of home environments and parents (different areas, economist status, parents, etc.) and then study outcomes throughout childhood.

While not planned, the split twins and triplets found each other as adults. This sparked them to trace back their adoption origin stories and learn of the study that purposely split them. Many of these children (now adults) suffered mental illness traced back to splitting apart young twin/triplet infants. Furthermore, for at least one set of siblings, Neubauer and Bernard withheld knowledge of mental illness in the biological mother, thereby potentially preventing early intervention.

Neubauer and Benard were not only studying the children adopted, but also their entire adopted families. Parents and siblings were unknowingly part of this research study as well. These family members were manipulated for research purposes, without their consent, for years without the researchers revealing the real purpose of the research or debriefing those impacted.

**Results**

Neubauer and Bernard never published the results of this research; instead, the papers remain locked-up at Yale. The subjects of his research and their families never were able to learn about the purpose of their participation.

## Discussion Questions

- What historical contexts might have enabled this research to happen?
- Who was harmed by the choices researchers made?
- Broadly speaking, what are the negative impacts of unethical research on the direction and future of science?

## Resources

Double Mystery↗ | *Lawrence Wright, New Yorker*
This article highlights the methodological approach and findings of a number of twin studies.

Three Identical Strangers↗ | *Director, Tim Wardle*
This documentary tells the life stories of a set of triplets involved as participants in the Secret Twins study.

## **Reproducibility and Open Science** | Discussion Guide

This discussion guide prompts dialogue about the challenge of reproducibility in empirical psychology research.

**How reproducible is social science research?**

Challenge youth to quiz their expectations of study reproducibility at Psychology results in top journals - can you guess which ones were true, and which didn't replicate?↗

Debrief as a team:

- Were you surprised by the results?
- What beliefs about reproducibility did you have before taking the quiz? Have those beliefs remained the same or have they changed in any way?
- If a study fails to replicate, does that mean it's a bad study?
- What are the consequences of a study failing to replicate?

Encourage youth to consider reasons a study might fail to replicate. This might include findings that are underpowered, publication bias toward sensational or flashy findings, questionable research practices, or outright fraud.

Support youth to find and read about a retracted study and document a case study to share with other youth (see examples in **Resources**). Then, ask each youth to share their case study, and invite the group to discuss:

- What factors led to the study's retraction?
- What practices might have helped discover the issue when it occurred (versus after the study had been published)?
- What, if anything, could the researchers have done to prevent this issue from occurring in the first place?
- As a consumer of research publications, what strategies can (or do) you use to critically assess research findings?

When possible, make time in youth's work schedules to read and discuss additional articles about reproducibility challenges in psychology (see **Research Ethics Resources** for suggestions).

**What is Open Science?**

As a group, watch The Open Research Lifecycle↗ (Center for Open Science) on YouTube and/or read An introduction to open science↗ (American Psychological Association). Lead, or invite youth to lead, a discuss supported by guiding questions, such as:

- How might open science practices help us improve reproducibility, catch fraud, and verify scientific findings?
- Do some open science practices seem more important than others? Are any missing?
- What could be some disadvantages to open science?
- What problems do open science practices not necessarily solve?

**Resources**

Retraction Note: The association between early career informal mentorship in academic collaborations and junior author performance↗ | *AlShebli, Makovi, & Rahwan; Nature Communications*
This memo describes the decision-making process that led to the retraction of a research article about early career academic mentorship.

Retraction Watch↗ | *Adam Marcus, Ivan Oransky*
This website documents and summarizes study retractions across all domains of science.

Why Rich Kids are So Good at the Marshmallow Test↗ | *Jessica McCrory Calarco, The Atlantic*
This article describes a conceptual replication of the classic Marshmallow Delayed Gratification study, and its failure to reproduce the original study's findings.

## **Research Ethics Resources** | Resource List

This resource list suggests readings and other media related to research ethics.

**Film & Video**

5 Psychology Experiments You Couldn't Do Today↗ | *SciShow*
This YouTube video summarizes classic examples of ethical violations in human subjects research.

Three Identical Strangers↗ | *Director, Tim Wardle*
This documentary tells the life stories of a set of triplets involved as participants in the Secret Twins study.

**Popular Press Articles**

1,500 scientists lift the lid on reproducibility↗ | *Monya Baker, Nature*
This article reports on psychology researchers' beliefs about and attitudes toward the reproducibility crisis.

Double Mystery↗ | *Lawrence Wright, New Yorker*
This article highlights the methodological approach and findings of a number of twin studies.

Fake TV Game Show 'Tortures' Man, Shocks France↗ |
*Eleanor Beardsley, All Things Considered*
This radio show summarizes a replication of the Milgram Obedience Study that took place in a fake reality show setting.

How Would People Behave in Milgram's Experiment Today?↗ |
*John Greenwood, Behavioral Scientist*
This article describes the implications of the Milgram Obedience Study and reviews subsequent replications.

Questionable Research Practices: Definition, Detection, and Recommendations for Better Practices↗ | *Ulrick Schimmack, I-Index*
This post describes common Questionable Research Practices and theorizes potential solutions.

The Lifespan of a Lie↗ | *Ben Blum, Medium*
This article offers a critique of the Stanford Prison Experiment and discusses the implications of that research on policy and culture.

The Mind of a Con Man↗ | *Yudhijit Bhattacharjee, The New York Times Magazine*
This article tells the story of an infamous fraud discovery in social science research and the implications for the field.

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| | The Stanford Prison Experiment was massively influential. We just learned it was a fraud.↗ \| *Brian Resnick, Vox*<br>This article explores Questionable Research Practices undertaken in the Stanford Prison Experiment and the subsequent impact on the validity of the study's findings.<br><br>What psychology's crisis means for the future of science↗ \| *Brian Resnick, Vox*<br>This article discusses the reproducibility crisis in psychology and its implications for future research efforts |
| **Peer-Reviewed Articles** | Estimating the Reproducibility of Psychological Science↗ \|<br>*Open Science Collaboration*<br>This article explores predictors for a psychological research study's reproducibility and potential problematic processes that may contribute to this issue.<br><br>Measuring the Prevalence of Questionable Research Practices With Incentives for Truth Telling↗ \| *John, Loewenstein & Prelec*<br>This article describes the most common self-reported Questionable Research Practices and scientists' perceptions of those practices. |

## **Research Questions and Methods** | Module

This module introduces youth to processes for developing meaningful research questions and methodologies.

**Goal #1** **Familiarize youth with processes for generating research questions.**

- Coordinate opportunities for youth to engage in lab meetings or job chats with researchers, focused on the guiding question: "How did you come up with your research question?" Invite youth to reflect on the many different motivations that may inspire research question generation.
- Ask youth to read a research article together (e.g., *Currency value moderates equity preference among young children*, see **Resources**), and then brainstorm potential future research questions that could be investigated. Encourage youth to reflect on their thought processes in developing a question of interest, and what variables would need to be taken into consideration (see **Study Design: Variables**).
- Provide youth with example research questions and invite them to brainstorm potential alternate and null hypotheses for each.

**Goal #2** **Build youth fluency in study design and methodology.**

- Introduce youth to key vocabulary and concepts used in study design through discussion and hands-on activities (e.g. **Study Design: Variables** & **Study Design: Correlational and Experimental Research**). Encourage youth to connect new terms back to their own research project and identify the features of that study's design.
- Engage youth to brainstorm as a group on the design of a mock study. During TSRCP piloting, youth developed a research question, identified variables of interest, and generated measures for a mock follow up study to one of the research mentor's ongoing projects.

- Hold regular **Writing About Methods** workshops with youth to clarify, iterate, and refine their study design. Support youth to document their methodology, such as by producing a methods summary for a poster, a study preregistration, a conference poster proposal, or the methods section for a journal article.

- Collaborate with youth to write a methods section for their research project and register the study on the Open Science Framework↗.

**Goal #3** **Engage youth in reflections about their own research positionality and reflexivity.**

- Invite youth to reflect on how their own identities, perspectives, and values impact their research (e.g., how they are framing questions, what design assumptions they are making). For example, during TSRCP piloting, youth contributed to a literature review about imagination in Informal STEM Education, and began their project work by engaging in a reflection session about their existing beliefs, perspectives, and assumptions about imagination.

- Use the **Drawing Conclusions from Data** guide to encourage youth to consider their positionality in practice, and establish reflection questions they can use when interpreting data.

- Engage youth in drafting their own positionality statement, using guiding questions from Marvette Lacy's *Just Tell Me What I Need to Know: Reflexivity and Positionality Statements* (see **Resources**).

**Resources**

Currency value moderates equity preference among young children↗ | *Blake & Rand*
This research study explored how the perceived value (favorite vs. least favorite) of a sticker impacted the number of stickers children were willing to share with another child.

Just Tell Me What I Need To Know: Reflexivity and Positionality Statements ↗ | *Marvette Lacy, Medium*
This article provides guiding questions to help researchers reflect on and frame their positionality statement.

## **Study Design: Variables** | Activity Guide

This activity introduces youth to key vocabulary used in designing research studies, with a focus on defining variables.

**Estimated Time:**

- 30 minutes

**Materials Needed:**

- 10 stickers of one type
- 10 stickers of another type
- Two envelopes
- **Variables Activity Worksheet**

### Activity Outline

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| **Model Methods** | Invite youth to play a research game with you, acting as faux "participants" in order to model the protocol of a child development research study.<br><br>The National Living Laboratory website includes a number of Research Toy activity guides, which provide examples of easy-to-model research studies. The materials listed above are used in the methods of the *"Stickers" Research Toy* (see **Resources**, below). |
| **Introduce Variables** | Using the Variables Activity Worksheet, introduce the different types of variables, and invite youth to discuss what elements of the study protocol they think were dependent or independent variables, and what control or extraneous variables they noticed.<br><br>*Optional: Ask youth to find and read a research study of their choosing; document the dependent, independent, control, and extraneous variables; and report to the group* |
| **Identify Variables** | Reflect together on the methods of an active study that youth have engaged with as data collectors. As a group, identify the dependent, independent, control, and extraneous variables for the study. |

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| **Select Variables** | Independently or in pairs, invite youth to select one the studies used above and brainstorm what a follow up to a study might look like. Encourage youth to pick one type of variable to focus on - e.g., they might decide to change the independent variable, select a new dependent variable to measure, or consider strategies to control for or measure an extraneous variable.<br><br>Provide guiding questions to support brainstorming, such as: What is the new research question? What might the method be? |
| **Resources** | Living Laboratory Research Toys \| *National Living Laboratory*<br>This webpage includes research articles and interpretation guides for a number of classic child development studies. |

## **Variables Activity Worksheet** | Worksheet

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| **Protocol Description** | ex. Researchers are studying the impact of sleep on test scores. A sample of high school students from the same math class are randomly assigned to either get 8 uninterrupted hours of sleep one night, or to receive 8 hours of sleep but with an alarm waking them every 30 minutes. Researchers measure test scores on a math exam conducted the following day. |
| **Dependent Variable**<br>the outcome being measured by the researcher | ex. Math test scores |
| **Independent Variable**<br>the variable(s) being controlled or manipulated by the experimenter | ex. Group assignment (uninterrupted or alarm-waking) |
| **Control Variables (Constants)**<br>variables being held constant in the experiment, which may impact the dependent variable | ex. Gender, Age |
| **Extraneous Variables**<br>variables that are not controlled in the experiment, which may impact the dependent variable (e.g., demand characteristics, experimenter bias, situational variables) | ex. General math ability, Interest in math, Sleep habits |

## **Study Design: Correlational and Experimental Research** | Discussion Guide

This discussion introduces youth to key vocabulary used in the design of research studies, with a focus on clarifying correlational versus experimental research.

**Correlational Study**

A correlational study measures 2 or more variables in order to determine the strength and direction of their relationship. In this type of research, researchers *do not* have control over the variables. There are no independent variables, as researchers are only measuring 2 or more variables that are already present. The results of a correlational study are not causal, meaning that researchers cannot conclude that one variable causes another.

**Experimental Study**

An experimental study involves researchers controlling independent variables, such as assigning subjects to a control or experimental group, and then measuring dependent variables. By the process of random assignment and sampling, experimenters can isolate a particular variable of interest and determine the causal impact it has on an outcome.

**Reflect**

Invite youth to review each of the real news headlines below and discuss whether the study described in the headline is correlational or experimental research.

- We Bond With Fictional Villains Who Resemble Us (Psychology Today)
- Facebook users get worse grades in college (NBC News)
- Credit Cards Can Make You Fat (SmartMoney)
- Grin and bear it: A smile or grimace may reduce needle injection pain, UC Irvine researcher shows (LA Times)
- Eating pizza ‘cuts cancer risk’ (BBC)
- Diet of fish ‘can prevent’ teen violence (The Guardian)
- Exercise is an all-natural treatment to fight depression (Harvard Health Letter)
- Conspiracy theory believers may have lower critical thinking skills *(Mashable)*

Encourage youth to elaborate on their thinking, using guiding questions such as: What factored into your conclusion that this study was experimental or correlational? What might that study design have looked like? Are there any headlines where either design is equally likely?

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| **Between-subjects Research** | In between-subjects research, each subject participates in only the experimental condition *or* the control condition. |
| **Within-subjects Research** | In within-subjects research, all the subjects participate in both the experimental and the control condition. Typically, within-subject designs help eliminate extraneous variables and increase statistical power, but these studies may also take more time and be more expensive to conduct than between-subjects designs. |
| **Reflect** | For any of the headlines above that youth determined would have been experimental studies, encourage them to consider whether it would have been more meaningful to run the study using a between-subjects or a within-subjects design. Ask youth:<br>○ What did you take into consideration when making that decision? |

## **Writing About Methods** | Discussion Guide

This guide prepares youth to translate their higher-order study design plans into a detailed description of a study's methods.

**Reflect**

Invite youth to reflect on or review research articles they have previously read. What kinds of information do they notice being documented in the Methods section?

**Operationalizing Variables**

Many research questions focus on developing a better understanding of abstract constructs (e.g., altruism, risk-taking behavior, curiosity). By operationalizing the constructs explored in the study, youth can more effectively find and develop meaningful measures.

Ask Youth:

- What are the independent and dependent variables? How are these operationally defined? (e.g., How will you measure "sharing"?)
- What variables will you need to control for? Are there any variables you can't control that might impact your dependent variable?
- What are the different conditions you will compare across? Will this be a within-subjects or a between-subjects design?

**Sample Characteristics**

Describing the target population for a research study helps define what measures will be developmentally appropriate and provides important context for the findings.

Ask youth:

- What are the characteristics of the population you will sample?
- How large will your sample be?
- How do you plan to recruit your sample, and are there any special human subjects considerations (e.g. audio-video recording consent requirements, study duration limitations, accessibility needs, warnings for potentially upsetting stimuli) to keep in mind?
- What requirements does the sample population have for ensuring accurate measurements (e.g., age appropriateness, language)?

**Developing an Instrument**

To ensure a method will be valid and reliable, it is important not only to describe what measures will be used, but also to justify *why* the measures selected are the best choices for answering the research question.

Ask youth:

- Will your measure include observational, behavioral, survey, or interview data (or some combination)?
- How will you ensure experimenter objectivity?
- Are these methods new, or have they been used before?
- [If used before]: Who developed the pre-existing measure? Will it need to be adapted for this study in any way? Why or why not?
- Why is this measure the best fit to answer your research question?
- Will any counterbalancing be required? Why or why not?

**Putting It All Together**

Once youth have responded to the above questions, provide opportunities to authentically document this work. You might invite youth to outline the methods section for a poster, respond to study pre-registration questions in the *Open Science Framework* (see **Resources**), or draft the methods section for a future research article.

It is important to acknowledge that as youth pilot their study design, their answers to some of these questions might change as they iterate on their measures. Support youth to revisit these questions throughout piloting and reflect on how methodological decisions are being made.

**Resources**

Open Science Framework - Templates of OSF Registration Forms↗ | *OSF*
This webpage provides a template to respond to the questions and instructions for an OSF pre-registration.

## **Data Collection** | Module

This module supports novice researchers to build competency and confidence in their data collection skills.

### Goal #1 Establish best practices for data collection consistency and validity

- Emphasize the importance of attention to detail during data collection. Encourage youth to take notes or create an annotated research instrument for their own reference.
- Invite youth to participate in protocol "dry runs" with staff or one another, and notice where, if at all, there are discrepancies in how the protocol is run (e.g. feedback language, how furniture is set up). Discuss as a group what inconsistencies emerge, and how to resolve them as a team.
- Encourage youth to film themselves running through a research protocol and watch the video back to observe their own verbal feedback, body language, or other behavior from a third person perspective.
- Discuss extraneous variables (see **Study Design: Variables**), and the potential impacts these can have on study outcomes - e.g. saying "Good job!" vs. "Okay!" after a child's response. Invite youth to brainstorm common extraneous variables, and how they may impact participant responses.
- Encourage youth to ask "Why?" frequently during data collection trainings. Building a deeper understanding of *why* a protocol is designed a specific way helps novice researchers to internalize the value of adhering to that process.

### Goal #2 Build youth confidence in recruiting and collecting data from the public

- Provide opportunities for youth to shadow expert data collectors and for expert data collectors to shadow and support youth. Pairing youth with a secondary researcher can help provide a "safety net" for when unexpected challenges come up during data collection.
- Create spaces for open dialogue between youth and other data collectors - to swap advice, to reflect on how data collection

sessions went, or to problem-solve unexpected challenges. During TSRCP piloting, youth used Microsoft Teams↗ and Slack↗ to communicate with one another and more seasoned data collectors.

- Host regular check in meetings with youth that encourage thoughtful reflection on their research strengths and opportunities for growth. During TSRCP piloting, youth engaged in a monthly one-on-one check in with both mentors (see **Youth Check In Template**).
- Encourage youth to review tips for engaging families in research during their museum visit that have been offered by experienced researchers (see **Recruitment Tips**) and to prepare their own recruitment pitches for potential participants. In addition to these tips, providing youth with opportunities to receive concrete advice from near peers (e.g., undergraduates) in-situ, as they shadow other researchers, will support them to notice and develop their own best practices.
- Invite near-peer researchers to reflect with youth on skills they've learned, how they've grown as data collectors, and approaches they use when working with the public. During TSRCP piloting, undergraduate research assistants working with Boston University's Social Development and Learning Lab shared reflections on their own experiences collecting data in the museum. Provide youth with opportunities for regular and frequent data collection practice. Ensuring that data collection is a regular part of youths' practice contributes to their ability to see their growth over time.

## **Recruitment Tips** | Handout

This resource offers a collection of recruitment and data collection tips from researchers who have significant experience conducting research in museums within the Living Laboratory↗ model.

1. **Look friendly and approachable.** Smile, orient yourself so visitors can see you, and use discretion when talking with other researchers so you look ready to interact.

2. **Be ready to leave the research area/your research setup and approach visitors to invite them or their children to participate in your study.** If you are concerned about leaving your stimuli alone, be strategic about how you set up your stimuli and move about the museum or bring another researcher to help you.

3. **Use exhibits to your advantage.** Learn more about the museum's exhibits so that you can use them as tools during recruitment and debriefing. You can also interact with the exhibits near the research area to "break the ice" with visitors and invite them to participate in the study once you're a familiar face.

4. **When you approach visitors, be mindful of what they are doing and how much time they may have to speak with you.** Visitors who are very engrossed in an exhibit may be less interested in participating immediately. If visitors are deeply involved in another activity, you shouldn't interrupt, but visitors frequently move between activities. If a group has just arrived, let them spend some time getting acclimated to the exhibit before you approach them. If a caregiver is struggling to keep an eye on multiple children, it is usually best to not distract them with an invitation to participate. Good times to talk with caregivers are when visitors are moving between activities or if they sit down near the research set up in the exhibit.

5. **Remember that everyone at the museum is interested in science in general, that visitors are here to learn and try new activities**. Be confident that your study will provide them with an interesting, educational, and fun experience at the museum. You are providing an opportunity to participate in science!

6. **Start by introducing yourself as a researcher or student affiliated with [the name of your lab's university].** Emphasize that the study is short (takes less than 15 minutes). Point the study set up as you explain to emphasize the legitimacy of your invitation.

   Sample introduction (5 second approach): "Hi, we're doing an experiment about [study topic] over there in case you want to check it out!" Then, point to the research setup, and pause for a moment. They may say no and come by later - that's fine!

7. **Prepare what you're going to say to visitors beforehand and practice how you will approach caregivers with a fellow researcher or museum staff member.** Having a short greeting in mind to introduce yourself and your study will help you feel comfortable approaching people. If you have inserts for the study available (e.g., caregiver handouts), bring them and pass them out to visitors as well. If a visitor says "no," thank them for their time.

   Sample introduction (long form): "Hi, my name is Jane Doe, and I am a student from Smith University. I'm interested in how children problem-solve, and wanted to see if your child would like to participate in our fun study. Our study is located in the corner over there, and we'll be here until 1 pm. Here's a handout describing our study in more detail. If you have any questions, please let me know. Thanks very much!"

8. **If your study is with children, you may want to approach the child in addition to caregivers.** Make sure to get down to the child's level. It may also be helpful to take a prop from your study with you (e.g., a puppet). If they seem interested in participating, approach the caregiver with more information before moving to the research area as a group.

   Sample introduction (for children): "Hi there! Do you want to play a game with me? We have an awesome game with stickers and stories. Let's see if it's okay with your grown-up!

9. **It is very common for a visitor to decline your invitation, and that's ok!** Visitors say "no" for a variety of reasons that usually have nothing to do with the researcher (e.g., time constraints, concerns about their child's mood, distrust of research in general, or simply not being interested). Thank them for their time and move on to other visitors.

10. **Ensure that participants understand the consent process.**
    After both caregiver and child have expressed interest, go over the consent process with them so that they understand what it means to participate and that they can stop at any time. Obtain signed consent forms before recording any information. Only a legal adult who is the child's legal guardian can provide informed consent to participate in your study.

11. **Allow all interested visitors to try out the study to learn more, even if you are not able to collect their data.** Visitors who are not eligible to be participants (e.g., are not with their legal guardian, outside of study age range, etc.) can still play the game for fun. Remember to count anyone who learns about your science (and is not a participant) as an educational opportunity in the shift log. Also, seeing another person engaged and having fun in the research area can draw other visitors (other potential participants) to be interested in finding out more.

## **Interpreting Data** | Module

This module supports youth to engage with data analysis and reporting.

**Goal #1** **Build youths' skills in making meaning from data or figures.**

- Support youth to recognize different types of data (e.g., qualitative, quantitative, continuous, discrete), and how a variable's data type influences how it can be coded, analyzed, and visualized. During TSRCP piloting, youth collaborated with mentors to create data entry spreadsheets for their research projects, reflecting on the appropriate coding schema needed to support later data analysis.
- Model inductive and deductive coding practices for qualitative data. During TSRCP piloting, mentors used the *Team-Based Inquiry Guide* (see **Resources**) to train youth in qualitative data analysis.
- Familiarize youth with the concepts of rich and lean data interpretation and examine existing research study results through those lenses. During TSRCP piloting, mentors used the **Drawing Conclusions from Data** guide to frame conversations about interpreting data.
- Provide opportunities for youth to reflect on existing data visualizations, and practice writing meaningful captions that summarize the key finding(s) represented in a visualization. During TSRCP piloting, one strategy mentors used to support youth in making meaning from existing data visualizations was to play a figure & caption matching game with youth.

**Goal #2** **Familiarize youth with technical platforms used to summarize and visualize data.**

- Introduce youth to data analysis platforms and create opportunities for youth to practice using new features and build their skills using exemplar datasets. During TSRCP piloting, youth primarily used Excel and R.
- Create fun challenges for youth to problem solve using the features of a data analysis platform. For example, during TSRCP, mentors created a fake dataset about people's pizza preferences, and challenged youth to find a strategy to identify and resolve all variations and misspellings of "pepperoni".

- Engage youth in a think-aloud walkthrough of their research project data. What analyses do they want to conduct? Work together to write code or construct a formula to run that analysis. What unexpected challenges came up? Model problem solving behavior as youth collaboratively work through their own data.
- Invite youth to "clean up" data visualizations using best practices from the **Data Visualization** guide.

---

**Goal #3** **Expand youths' vocabulary for, understanding of, and facility with basic statistics.**

- Ask youth about their prior experience and comfort with statistics. You may find a range of existing knowledge among youth participants; be prepared to adjust your approach to ensure the conversations and activities you have planned are reflective of the group's needs. Youth who participated in TSRCP piloting were generally comfortable with some descriptive statistics (mean, median, mode, min, max), but most were unfamiliar with variance, standard deviation, and inferential statistics.
- Invite youth to use descriptive statistics (e.g. mean, median, mode) to characterize their data. From these summary statistics, encourage youth to describe what meaning begins to emerge for them about the data.
- Introduce youth to common inferential statistical tests used in reporting human subjects data. During TSRCP piloting, mentors found it more meaningful to begin by building understanding of how these tests were reported in study results sections and decoding their meaning (e.g., What should I look for in a p-value?), and fold in training on how these tests are calculated later on.
- Familiarize youth with commonly used reporting terms such as "statistically significant" and "effect size", and what they mean in the context of a study's conclusions.
- Engage youth in dialogue about common fallacies in the interpretation and use of statistics. Guiding questions include: Should we assume a statistically significant research finding applies to a population that the study did not originally include? What are potential consequences of HARKing (Hypothesizing After Results are Known)?

**Resources**

Team-Based Inquiry Guide↗ | *NISE Network*
This guide provides a practical approach for introducing and training education practitioners in the process of evaluation.

## **Statistics Resources** | Resource List

This resource list shares training tools and theoretical readings to support youth training in statistical analysis.

| | |
|---|---|
| **From Data to Viz↗**<br>*Yan Holtz & Conor Healy* | This website provides decision trees to select appropriate data visualizations for different types of data, and shares code templates for use in R. |
| **How to Lie with Statistics↗**<br>*Darrell Huff* | This book introduces readers to common statistical tests, and how data can be biased or manipulated to produce specific results. |
| **Most People are not WEIRD↗**<br>*Heinrich, Heine, & Norenzayan; Nature* | This article discusses the danger in generalizing research findings to populations not included in the original study. |
| **R and R Studio↗** | R is a statistical programming language that supports analysis and visualization of research data. R Studio is a free, open source software that allows users to work with the R programming language in a user-friendly environment. A number of downloadable packages are available to install. |
| **R Swirl package↗** | Swirl is a downloadable add-on package for R that offers users an orientation and basic training on R in an interactive and game-like format. |
| **R Markdown package↗** | Markdown is a downloadable add-on package for R that transforms the R Studio environment into a “lab notebook,” which allows users to create, annotate, and execute code; document products and visualizations of data; and generate research reports, within a single file. |
| **R ggplot2 package↗** | ggplot2 is a downloadable add-on package for R that adds functionality and simplifies the process of creating data visualizations. |
| **R for Data Science↗** | This website provides training and practicums for working with data in R. |

## **Drawing Conclusions from Data** | Discussion Guide

What can we tell from a study's design, data, and results – and what can't we tell? This discussion prepares youth to make meaning of research results and avoid common fallacies in data interpretation.

**Understanding Parsimony**

Parsimonious interpretation of data (finding the simplest accurate explanation for a study's results) is a best practice for ensuring that conclusions derived from the data and are free of unsupported assumptions. It is important for researchers to recognize their existing biases toward *rich interpretation* of data (ascribing findings to underlying cognitive processes or understanding) or *lean interpretation* of data (minimally attributing findings to cognition, unless explicitly demonstrated), and how to adjust their assumptions accordingly.

Invite youth to read the first study example in the **Drawing Conclusions Worksheet** and discuss the rich and lean interpretations of the finding.

Invite youth to consider:

- Do you tend to be more in agreement with one explanation over the other? Why?
- Is there a third explanation that you think is more accurate?
- Are there any unsupported assumptions that emerge in either of these explanations? How might you conduct a follow up investigation to gain more information (e.g. by controlling for unpredicted variables, conducting an experiment to test a specific claim)?

**Practicing Interpretation**

Encourage youth to work together to brainstorm rich and lean interpretations of the second and third research study in the worksheet.

Invite youth to consider:

- What was your gut interpretation of the data? If you were to imagine a spectrum from the most rich interpretation of the data to the most lean, where would your interpretation fall?
- What potential fallacies might emerge from the rich interpretation?
- What might be missing from the lean interpretation?
- These results are from studies conducted with young children. Do you think your interpretation might be different if these studies were done with adults?

**Drawing Conclusions**

As youth analyze their own data, make time for them to meet with study stakeholders and discuss their interpretation. It may be helpful to encourage youth to document their own interpretation in advance of discussing with more senior researchers, to help them feel more comfortable in discussion where there may be a range of interpretations.

During discussion, invite youth to consider:

- Why might there be disagreement about the interpretation of the results?
- What assumptions or prior knowledge are individuals bringing to the discussion that might shape their interpretation?
- How do researchers resolve disagreements about interpretation? What steps can be taken to ensure parsimonious interpretations of the results?
- Will any counterbalancing be required? Why or why not?

## **Drawing Conclusions Worksheet** | Worksheet

| Example Results | Rich interpretation | Lean interpretation |
|---|---|---|
| Hamlin, Wynn, & Bloom (2007)↗ found that after viewing a puppet show in which a "helper" puppet helped another achieve a goal while a "hinderer" puppet prevented the puppet from its goal, 6m and 10m old infants preferred the "helper" puppet when given both to select from. | *Ex: Infants as young as 6m have an innate social understanding, probably present from birth. These infants are able to make moral assessments and use that information to shape their own preferences in selecting playmates. Non-selection also serves as punishment to the "hinderer" puppet.* | *Ex: The "hinderer" puppet created more audio noise when "smashing" into the target puppet, thus children were aversive to the noise-making puppet, not attending to morality at all.* |
| Repacholi & Gopnik (1997) ↗ found that 18m old infants, but not 14m old infants, will share an adult's preferred snack with them. | | |
| Bonawitz et al (2011)↗ found that children aged 4 to 6 years discovered more features of a novel toy when given no instruction than when instruction was provided. | | |

## **Evaluation in Museums** | Module

This module provides an introduction to evaluation practices and supports youth in making connections between research and evaluation processes.

**Goal #1** **Leverage overlap between evaluation processes and research processes to build cross-cutting skills.**

- Train youth to conduct evaluation protocols, highlighting skills that crossover from their research projects. During TSRCP piloting, youth learned to collect data for the Museum's *COVES* initiative (see **Resources**) and designed and led a front-end evaluation on museum visitors' perceptions of artificial intelligence technologies.
- Familiarize youth with practical training resources for evaluators (e.g., *Team-Based Inquiry* and *AEA365*, see **Resources**), and debrief on how these tools may be incorporated into their practice. During TSRCP piloting, youth engaged in the **Developing Evaluation Instruments** activity to build their skills in developing measures and creating data collection tools.
- Compare and contrast research and evaluation study goals, processes, and applications with youth (see **Evaluation 101** for guiding questions).
- Invite youth to participate in meetings with project constituents; this offers opportunities to shadow the decision-making processes for the evaluation and provides context for translating evaluation findings into recommendations for educational practice.
- Coordinate **Community Connection Chats** with evaluators and encourage youth to notice similarities and differences across researchers' and evaluators' career paths, training requirements, and project opportunities.

**Goal #2** **Build youth understanding of their own role as participants in an evaluation, if applicable.**

- If youth are engaged as participants in an evaluation study (as TSRCP youth were), invite them to discuss the study's goals, measures, and practices; this supports youth to better understand the evaluation they themselves are participating in.
- Engage youth in member-checking practices, which involves inviting youth to collaboratively interpret data with the evaluators. During TSRCP piloting, this practice gave youth participants an opportunity to reflect on their own responses for the program and allowed evaluators to gain a more nuanced understanding of youths' survey responses.

**Resources**

AEA365: A Tip-a-Day By and For Evaluators↗ | *American Evaluation Association*
This blog provides brief informational posts to deepen evaluators' skills and practice.

COVES Website↗ | *Collaboration for Ongoing Visitor Experience Studies*
COVES, or the Collaboration for Ongoing Visitor Experience Studies, is a cross-institutional project which seeks to better understand visitor demographics, motivations, and experiences at museums across the United States.

Team-Based Inquiry Guide↗ | *NISE Network*
This guide provides a practical approach for introducing and training education practitioners in the process of evaluation.

## **Evaluation 101** | Discussion Guide

This discussion guide supports youth understanding of evaluation in relation to science research.

**Introduction**

While *research* typically focuses on generating new, generalizable knowledge, *evaluation* focuses on collecting data that can be applied to support informed decision-making.

**Share experiences**

Invite youth to share any experiences they've had engaging with research or evaluation before (either as a participant, or as a researcher/evaluator).

Consider unexpected experiences that youth may have had (e.g., rating their experience with a customer service rep, evaluating a teacher or class in school, taking a survey about what they want their prom to look like).

Ask youth:

- What kinds of things were involved in that experience?
- What did it feel like to be involved (as a participant/as a researcher/as an evaluator)?
- What was the goal of the experience?

**Familiarize**

Provide time for youth to familiarize themselves with research projects or evaluation projects led (or used) by your institution. This might involve reading a research article or report, talking to a project's constituents, or being directly embedded in the work of that project.

**Compare**

As youth become more familiar with both types of projects, encourage them to reflect on the research process, and make comparisons to the evaluation process.

Ask youth where they see similarities or differences in:

- the phases involved in the process?
- human subjects considerations?
- the kinds of tools or instruments used?
- how data is analyzed?
- how and where findings are reported?
- the application of the findings?
- the timeline for completing a study and sharing the findings?

| | |
|---|---|
| | Make use of graphic organizers, process overview documents, book chapters, websites, or other media to introduce youth to the framework of evaluation (see **Resources** for suggestions). Invite youth to broadly reflect on what skills or practices are involved in evaluation, and how that compares to skills and practices involved in research. |
| **Evaluator Identities** | If time allows, engage youth in the **Meaning Mapping Activity**, adding a third category for "evaluator/evaluation". What connections emerge for youth? |
| **Resources** | Center for Advancement of Informal Science Education↗ \| *CAISE*<br>The informalscience.org website includes a community repository with links to a number of informal science education (ISE) evaluation projects.<br><br>Guiding Principles for Evaluators↗ \| *American Evaluation Association*<br>This website provides an overview of the core values of the American Evaluation Association, and serves as a guide for ethical conduct for evaluators.<br><br>Team-Based Inquiry Guide↗ \| *NISE Network*<br>This guide provides a practical approach for introducing and training education practitioners in the process of evaluation. |

## **Developing Evaluation Instruments** | Activity Guide

This activity invites youth to critically reflect on evaluation methodology. Youth develop their own evaluation criteria and data collection instrument to determine "What makes a good chocolate chip cookie?"

This activity guide draws inspiration from *Building evaluation capacity: Activities for teaching and training* (see **Resources**, below).

**Estimated Time:**

- 45 minutes

**Materials Needed:**

- **Cookie Instrument Development Worksheet**
- Three (or more) different types of pre-packaged chocolate chip cookies (or choose an allergy friendly alternative)
- Writing instruments

**Activity Outline**

| | |
|---|---|
| **Brainstorm** | Ask youth to discuss what they think makes a good chocolate chip cookie. Document notes in a shared space (e.g., Jamboard↗, whiteboard, giant sticky note). Youth may find these initial brainstorming notes useful when establishing their evaluation criteria. Invite youth to identify which elements are most relevant or important to them. |
| **Establish Criteria** | Break up youth into small groups or pairs and ask them to use the Cookie Instrument Development Worksheet to establish 4-5 criteria for evaluating the cookies - these are the cookie elements or dimensions they will be focusing on for their evaluation. For example, youth may decide they would like to evaluate the cookies based on the size of the cookie, the average number of chocolate chips per cookie, or the texture of the cookie. For an added challenge, encourage youth to include both qualitative and quantitative criteria. |
| **Construct Standards** | Next, invite youth to construct standards for each criterion they have established. Here, youth should be thinking about how well a cookie *should* perform across each dimension - for example, if youth identified "cookie size" as an important dimension for measuring cookie quality, they may decide that the standard for a "good" cookie is an average diameter of 4 cm. |

| | |
|---|---|
| | Ask youth to document how they plan to gather information for each criteria and compare their data for each cookie brand to the standards they have established. Youth should consider what criteria might be objectively measurable (e.g. # of chips per cookie), and what data might be subjective and require gathering information from others (e.g. ranking chewiness).<br><br>Finally, invite youth to use the information they established in their worksheet to create a data collection instrument they can use to evaluate each cookie's performance. Ideally, for each cookie brand/type, youth should collect multiple data points |
| **Data collection and analysis** | Support each group to lead data collection using the instrument they developed. This may involve using observation tools, surveying others' perceptions of the cookies, or eating the cookies themselves. As youth collect data, encourage them to notice what elements of their instrument are working well, and whether any elements could use revision.<br><br>Once youth have collected data on each cookie, invite them to compare their measurements back to the standards they have established, and decide which cookie(s) best meet or exceed those standards. Ask each group to report out on their findings and encourage the youth to reflect on similarities and differences in methodologies and outcomes across groups. Youth may notice that different groups came to different conclusions, or that the cookie that best met the standards was not their expected "winner" - invite them to consider why that may be, and how that might impact their evaluation approach if they were to try the activity again. |
| **Resources** | Building evaluation capacity: Activities for teaching and training (2nd ed.) ↗ \| *Preskill & Russ-Eft*<br>This book shares practical knowledge and tools to support learning about evaluation. |

## **Cookie Instrument Development Worksheet** | Programmatic Tool

### ▶ What cookie is worth eating?

| **Criteria**<br>What dimensions should be used to judge the cookie? | **Standards**<br>How well should the cookie perform? | **Measuring**<br>How will the cookie's performance be measured? |
|---|---|---|
| cookie size | >4 cm average diameter | measure diameter in cm with a ruler |
| | | |
| | | |
| | | |
| | | |
| | | |

# 03 | Science Communication

## **Communicating with Professional Audiences** | Module

This module trains youth to communicate science with professional audiences.

### Goal #1 Introduce youth to science communication practices.

- Provide opportunities for youth to learn from expert science communicators (see **Community Connection Chats**), for example by participating in lab meetings, webinars, and informal discussions with psychology and educational researchers.
- Encourage youth to consider how the norms of conversation might differ between audiences. Ask youth if they've talked about their current work with others in their lives (e.g., friends, family, teachers, interviewers). Reflect together on how the *way* they describe their work changes based on who they are describing it to.
- Familiarize youth with resources and tools used to develop science communication products (see **Data Visualization**, **Poster Development Guidelines**), and reflect on the use of such tools in research media.
- Engage youth in regular opportunities to review and make meaning of science communication products intended for professional audiences (e.g., research articles, research posters, study registrations).

### Goal #2 Provide opportunities for youth to practice their science communication skills with professional audiences across contexts.

- Invite youth to co-develop science communication products with mentors/colleagues and solicit feedback on communicating their work.
- Offer practicums (e.g., **Data Visualization**, **Poster Development Guidelines**) for youth to develop science communication products related to their project work
- Coordinate opportunities for youth to formally present research products (e.g., poster) with professional audiences (e.g., lab members, museum staff, conference attendees). During TSRCP piloting, youth co-authored with mentors and submitted a poster proposal to a conference, which was ultimately accepted and presented by youth.

## **Data Visualization** | Activity Guide

This activity supports youth to craft meaningful and easy to comprehend data visualizations and offers youth an opportunity to reflect on and make good decisions about how to represent their data.

**Estimated Time:**

- 30 - 45 minutes

**Materials Needed:**

- Butcher paper and markers (Jamboard↗, if virtual)
- Index cards

### Activity Outline

| | |
|---|---|
| **Share Out** | While there are numerous ways to visually represent data, certain types of data visualizations tend to be more common in reporting research findings. Ask youth to share about the types of data visualizations they are familiar with or have seen before (e.g., bar graph, scatter plot, histogram). In some cases, youth may be familiar with a particular visualization type, but not know the name - they can draw or describe the visualization instead. |
| **Describe Data** | Discuss the kinds of data that are used in each type of visualization (e.g., categorical, numerical, continuous, discrete). If desired, youth can play with the decision tree in *From Data to Viz* (see **Resources**) to visually explore how different data types are suited to different types of visualization. |
| **Brainstorm Variables** | Ask youth to brainstorm 5 different variables, recording each variable on its own index card. Encourage each youth to generate at least two numeric and two categorical variables (e.g., number of candy corn consumed, eye color, steps walked). Shuffle all youths' index cards together. |
| **Small Group Visualization** | Break youth into pairs or small groups and ask each team to select two cards at random. The team should then identify the data type of each variable and select an appropriate data visualization.<br><br>Give each team time to create a visualization that represents a relationship between their two variables (e.g., a box plot showing the median number of candy corn consumed by eye color). Remind them to consider elements such as axes labels, legends. |

**Critique and Reflect**

Ask each team to present their data visualization back to the full group and invite the "audience" to share feedback:

- Does the type of visualization make sense for the data being presented?
- What features of the visualization, if any, helped you as an audience member to understand the data?
- What features of the visualization, if any, made it hard for you as an audience member to understand the data?

Provide time for each team to revisit their data visualization and revise based on feedback from their peers. Encourage teams to consider how design features (e.g., colors used, order of data, font size, wording of labels) may support meaning in their second draft. Debrief as a group and discuss what changes were made and why.

If time allows, explore examples of good and bad data visualizations as a group (see **Resources** for examples), and reflect on common pitfalls to avoid.

**Resources**

From Data to Viz↗ | *Yan Holtz & Conor Healy*
This website provides decision trees to select appropriate data visualizations for different types of data, and shares code templates for use in R.

WTF Visualizations↗ | *Author unknown*
This blog shares examples of ineffective, misleading, and wacky data visualizations.

## **Poster Development Guidelines** | Activity Guide

This activity supports youth to build a toolkit of effective academic poster design strategies and invites critical evaluation and reflection on exemplar posters.

**Estimated Time:**

- 90 minutes

**Materials Needed:**

- **Poster Development Resources**
- **Poster Development Tips Worksheet**
- Exemplar Posters (see **Resources**)
- Sticky Notes
- Giant sticky or butcher paper
- Markers

### Activity Outline

**Compare**

Compare and contrast academic research articles, academic research posters, and popular press articles. Invite youth to consider:

- What are the goals for each product?
- Who is the intended audience for each project?
- What is the scope of information communicated in each product?

In pairs, ask youth to read one of the resource guides from the Poster Development Resources list. Using the information from their guide, invite youth to contribute notes to a shared copy of the Poster Development Tips Worksheet.

**Group Review**

Hang exemplar research posters around a room for youth to review using the notes they documented (examples can be found in **Resources**, below). Mentors might also invite youth to review and reflect on posters authored by mentors or their colleagues. Direct youth to circulate between posters and use sticky notes to highlight examples of effective or ineffective science communication and design.

As a group, review the stickies on each poster and debrief on the themes that emerged. Invite youth to consider:

- What features made a poster stand out as especially effective or interesting?
- What features made a poster uninteresting or hard to comprehend?
- Which poster do you think was most effective? Why?

**Poster Design**

Break youth into small groups and provide them with a giant sticky or butcher paper (ideally, sized to standard poster dimensions). Keeping in mind their notes and the themes that emerged in their debrief, encourage youth to draw a rough sketch of how they would design a research poster.

Invite youth to choose between a study they are running, a research article they have read, or a research toy interpretation they have learned and outline a poster for that work. Remind youth that this is a rough sketch, so it is appropriate to use faux text, bullets, and other placeholders to communicate their plan (e.g., "table caption goes here" versus writing a formal caption).

**Share Out**

Come together as a full group and invite each team to share their poster. Ask them to describe the decisions they made in developing their rough sketch, any best practices they used in their design, or any lingering questions about how to best communicate their study.

When youth are at a point in their project work where they are producing a real academic poster, encourage them to revisit their co-created version of the Poster Development Tips document, and use the practices they identified with their team.

**Resources**

Exemplar Poster: Alternative approach in rehabilitating the chronically laminitic foot using composite materials↗ | *Daisy Bicking, colinpurrington.com*

Exemplar Poster: Context or Composition? What Explains Variation in SCHIP Disenrollment?↗ | *Phillips, Miller, Cantor, & Gaboda, Health Services Research*

Exemplar Poster: Pigs in space: effect of zero gravity and *ad libitum* feeding on weight gain in *Cavia porcellus*↗ | *Colin Purrington, colinpurrington.com*

Exemplar Poster: Why does anther color vary in trout lily?↗ | *Austen & Forrest, Better Posters*

Exemplar Posters: How to Make an Effective Poster↗ (slides 45-47) | *Stuckey & Hoyer, UC Davis*

## **Poster Development Tips Worksheet** | Worksheet

Review the readings from **Poster Development Resources** to contribute tips and best practices to this shared tool. An example of a completed tool can be found in the ***Appendix*:** “Poster Development Tips - Example”.

| **Formatting Guidelines** | |
|---|---|
| **Layout** | |
| **Graphics** | |
| **Text** | |

| Content Guidelines | |
|---|---|
| **Title and Authorship** | |
| **Introduction** | |
| **Methodology** | |
| **Results** | |

| | |
|---|---|
| **Data Visualizations**<br><br>(e.g. Tables, Graphs, Figures, Charts) | |
| **Conclusions** | |
| **References** | |
| **Acknowledgements** | |
| **General Considerations** | |

## **Poster Development Resources** | Resource List

This resource list offers readings, tips, templates, and guidelines to support youth in developing engaging research posters.

### Guidelines

| | |
|---|---|
| **10 Tips on Writing a Research Poster↗**<br>*BiteSize Bio* | This site offers strategies for organizing information in a research poster. |
| **Better Posters↗**<br>*Zen Faulkes, Better Posters* | This blog offers educational critiques of research posters (with authors' permission), and posts regularly about design and tech tips. |
| **Creating an Effective Scientific Poster↗**<br>*Jennifer Spall, University of Guelph* | This guide provides a checklist of best practices for poster design. |
| **Designing conference posters↗**<br>*Colin Purrington* | This site provides an overview of typical poster formats, as well as "Dos and Don'ts" for poster design. |
| **How to Make a Better Poster↗**<br>*Matthew Stuckey & Tammy Hoyer, UC Davis* | This presentation guides readers through best practices in poster and graphic design. |
| **Preparing and Presenting Effective Research Posters↗**<br>*Jane Miller, Health Services Research* | This article shares methods for preparing digestible research posters for a range of audiences. |
| **Writing Workshop: Talks and Posters↗**<br>*Barbara Sarnecka, Sarnecka Lab Blog* | This guide provides a list of strategies for creating a compelling academic presentation. |

## Design Tools

| | |
|---|---|
| **PosterPresentations.com ↗** | This website provides free PowerPoint templates for academic research posters. |
| **The Noun Project ↗** | This website provides millions of free downloadable icons and stock photos. |
| **WhoCanUse ↗** | This free website allows users to check for accessibility (e.g., color contrast), using widely adopted web accessibility standards. |

## **Communicating with Public Audiences** | Module

This module trains youth to engage public audiences through science communication.

**Goal #1** **Deepen youth's understanding of public science communication practices.**

- Provide youth with opportunities to shadow expert public science communicators. During TSRCP piloting, youth were paired with more senior lab personnel when attending their first research shifts, and were encouraged to reflect on the strategies used by these researchers using the **Scaffolding A Research Debrief** tool.
- Invite youth to consider how the norms of conversation might differ for various audiences. Ask youth if they've talked about their current work with others in their lives (e.g. friends, family, teachers, interviewers). Reflect together on how the ways they describe their work changes based on who they are describing it to.
- Familiarize youth with different principles of science communication (see **Effective Science Communication**, **Evaluating Popular Press**), and encourage them to observe how those principles are applied (or not) in different science communication products.
- Engage youth in a regular book club (see **Book Club Overview**) to provide them with opportunities to read and reflect on popular press material about cognitive and child development research.

**Goal #2** **Provide opportunities for youth to practice public science communication in varying contexts.**

- Create opportunities for youth to prepare for and practice debriefing others on their research study in advance of leading discussions with the public. During TSRCP piloting, youth used the **Scaffolding A Research Debrief** tool to organize their thoughts into semi-structured "standard" debriefs, which allowed them to create a safe starting point for dialogue.

- Train youth to take on the role of a lead research assistant for research shifts in the museum, and offer regular opportunities to communicate with Museum visitors about their research.
- Engage youth in developing study inserts, using the **Insert Development** training as a framework. During TSRCP piloting, providing youth with opportunities to summarize their research in this format helped to build a foundation for other science communication products (e.g. caregiver debrief, research poster).
- Train youth to interpret the methods and results of classic child development research studies with the public, using *Living Laboratory Research Toys* (see Resources). Provide youth with opportunities to shadow expert Research Toy facilitators and learn how to disseminate research in a flexible and appropriately scaffolded manner.
- Coordinate events for youth to informally present research products (e.g. a poster) with public audiences, including family, friends, and general museum visitors

**Resources**

Living Laboratory Research Toys↗
*National Living Laboratory*
This webpage includes research articles and interpretation guides for a number of classic child development studies.

## **Insert Development** | Activity Guide

In this activity, youth review criteria for writing caregiver handouts, evaluate exemplar text for handouts, and draft text for a handout about their own study.

This activity guide draws inspiration from resources developed by the National Living Laboratory initiative (see **Resources**).

**Estimated Time:**

- 30 - 45 minutes

**Materials Needed:**

- *Living Laboratory Insert Template* (see **Resources**)
- *Insert Text Examples: Pre/Post Editing* (see **Resources**)

### Activity Outline

**Introduce**

In the Living Laboratory↗ model, study "inserts" are science communication products that describe a study's question and methods for the public, and suggest related activities for families to explore both in the museum and at home.

Much like study abstracts, inserts provide a quick snapshot of the research for a reader. However, while study abstracts are primarily written for a professional audience and are a part of a completed, published study, inserts are primarily written for public audiences and describe a study that is ongoing.

**Assess**

Share the *Living Laboratory Insert Template* and invite youth to notice and discuss similarities and differences between study abstracts and inserts.

Provide youth with the content from one of the samples in "Section 1: Inserts that needed very little editing" from the *Insert Text Examples* document (hide or cut off the notes section). As a group, read the insert text, and ask youth to assess the insert for the following criteria.

Does the text describe:

- The research questions?
- The research methods?
- How participants' responses will be measured?
- The "why" of the research question?
- Is there any confusing jargon or vocabulary?
- How easy is it to understand the "main point" of the insert?
- Is the amount of information too much, too little, or just right?

| | |
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| **Small Group Review** | After evaluating the first insert together, break youth into pairs and provide each group with one of the other example inserts to review. Keeping the same criteria in mind, ask youth to review and provide feedback on that insert's text |
| **Make Edits** | Gather the group together and debrief on the feedback they shared. Then, break back out into pairs, and ask youth to make edits to their insert, based on their feedback and the guidelines set forth in the Living Laboratory Insert Text Template. |
| **Swap and Debrief** | Invite pairs to swap their drafts and document feedback on one another's content using the review criteria.<br><br>Debrief as a group on writing strategies used and feedback shared. |
| **Resources** | Study Inserts: Development Guidelines, Templates & Samples↗ **|** *National Living Laboratory*<br>This resource provides tools for writing and evaluating study inserts. The webpage includes files for the *Living Laboratory Insert Template* and *Insert Text Examples: Pre/Post Editing*. |

## **Effective Science Communication** | Activity Guide

This activity supports youth to recognize and apply best practices in communicating science with public audiences.

**Estimated Time:**

- 60 minutes

**Materials Needed:**

- **Elements of Science Communication Reflection Tool**

### Activity Outline

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|---|---|
| **Discuss** | While specific science communication strategies may differ between audiences, formats, and content, a number of general principles and best practices can be applied across contexts. Share the Elements of Science Communication Reflection Tool with youth and discuss each of the four principles in the left-hand column.<br><br>For each principle, invite youth to reflect and share their thoughts on how that principle may impact a person's learning experience. Consider "Quantity" as an example: What is the potential impact of an author or speaker communicating too little content? Too much content? Just the right amount of content? |
| **Evaluate** | Provide an opportunity for youth to individually evaluate existing content through the lens of these four principles. Invite youth to engage in a science communication experience, documenting their notes using the Reflection Tool. The experience youth reflect on could be visiting a museum exhibit, reading a popular press article, attending a program or webinar, or viewing a film. |
| **Debrief** | Come back together as a group and debrief on youth's reflections. Ask youth: What strategies did authors/speakers employ that assisted in/hindered public understanding? To what degree did these principles impact the learning experience? |

| | |
|---|---|
| **Write** | Engage youth in a science communication writing practicum. Ask each person to pick a STEM topic they are passionate about and write a maximum 280 character blurb about it (the length of a tweet on Twitter↗). Encourage youth to imagine they are writing for an audience that knows nothing about their topic, and to consider the principles from the Reflection Tool while drafting their content. |
| **Reflect** | Reflect together on the writing experience. Invite youth to discuss:<br>○ How easy or challenging was this process for you? What about the process made you feel that way?<br>○ How did the character limit impact your content decisions? How did this impact your writing style?<br>○ Were there any specific strategies you employed that you found useful?<br>○ Which principle felt easiest to address? Most challenging? |

## **Elements of Science Communication Worksheet** | Worksheet

### Quantity

*How does the author or speaker get the point across? Does this happen in a concise way?*

*Does the source include all the information necessary to understand the topic?*

### Quality

*Where is the nature of the source? What makes the source trustworthy or untrustworthy?*

*Does the source present information that is not supported by evidence?*

### Relation

Is the information in the source relevant to the topic covered?

How does the author/speaker bridge or connect disparate ideas together?

### Comprehension

Are there any portions of the source that are ambiguous or unclear?

How does the author/speaker convey difficult or unfamiliar concepts in a way that is understandable to the audience?

## **Scaffolding A Research Debrief Worksheet** | Worksheet

After a group participates in your research study, make sure you share a debrief that grounds their experience in your research question and methods. A visitor may be ready to chat at length about your research or may need to run off to another experience. Use this guide to prepare a debrief that can be flexible and responsive to the needs of your participant.

| **For participants that are ready to…** | **Debrief Learning Goals**<br><br>What do you want the participant to take away? | **Debrief Outline**<br><br>What do you plan to say, and how will you communicate it? | **Special Considerations**<br><br>Is there any jargon to avoid? Useful examples to share? |
|---|---|---|---|
| **Run to the Next Experience** | | | |
| **Hear Your "Elevator Speech"** | | | |
| **Engage in Conversation** | | | |

## **Evaluating Popular Press** | Discussion Guide

Popular press serves as an important access point to science and science research for many people. This discussion engages youth to think carefully about how to present their content in a way that is digestible and meaningful for all audiences.

**How can research be made more accessible to public audiences?**

Ask youth to read the news article University of California Drops Elsevier Contract↗ (Sarah Zhang, The Atlantic). This article discusses the role publishers play in the research lifecycle and in deciding who gets access to peer-reviewed science research.

Invite youth to discuss:

- What is your reaction to this article?
- Beyond journal articles, what other formats have you seen researchers use to disseminate research findings within academic communities?
- In what ways can researchers share findings with the public?
- Can you think of any strategies that might help increase access to research for people who don't already have that access?
- While many research articles require a paid subscription or institutional login, there has been a more recent trend toward publishing in open-access journals. What potential impacts do you imagine this might have?
- Do you think open-access publishing is enough to connect the public with science research? Why or why not?

**How do you access science research?**

Writing about research in popular press (e.g., books, magazine or newspaper articles) and documenting work in other public-facing media (e.g., blogs, podcasts, social media) are both common ways for scientists to disseminate their work in a format that is accessible to non-scientists.

Reflect together:

- Outside of journal articles, where have you seen, read, or heard about research findings?
- What similarities exist between journal articles and popular press articles? What is different about these formats?
- What assumptions do you have about the audience of a journal article? What assumptions do you have about the audience of a popular press article?

**How can you identify examples of "good" public-facing science writing?**

Youth have likely already encountered both good and bad science writing in their lives and have mental frameworks or criteria for assessing what makes for a "good" popular press piece.

Using a whiteboard (or Jamboard, if virtual), present youth with 3 dimensions to measure the quality of science writing:

- What makes it **trustworthy**?
- What makes it **easy to comprehend**?
- What makes it **interesting or relevant to your life**?

Invite each individual to use sticky notes to document their brainstormed ideas about criteria for good popular press, recording one idea per sticky note (e.g., providing a link to the original research, using simple language). Youth should map their stickies to one or more of the three dimensions (or define new dimensions, as needed), and reflect as a group on any common themes that emerge.

**Evaluate**

In pairs or small groups, ask youth to read 2-3 popular press articles describing research findings (for suggestions, see **Resources**, below). Ideally, provide youth with a mix of higher and lower quality popular press, to allow for critical reflection on a range of science writing approaches.

Ask youth to evaluate each article using the criteria they previously defined (across the dimensions of trustworthiness, comprehension, and relevance).

**Debrief**

Debrief as a team on each pair/group's evaluation, and discuss:

- What criteria felt most important to you when evaluating the overall quality of the article?
- Were there any additional criteria that emerged as you read the article?

Did any articles include both "good" and "bad" qualities? How did you reconcile that information?

**Resources**

Becoming Smarter than a 5th-Grader↗ | *Nancy Werteen, WFMZ News*
This article offers research-based suggestions to increase children's intelligence.

How to make this winter not totally suck, according to psychologists↗ | *Sigal Samuel, Vox*
This article provides tips from psychology literature to practice mental wellness during the COVID-19 pandemic.

Study: Smelling Farts May Be Good for Your Health↗ | *Meghan Demaria, The Week*
This article shares findings from a study that explored the role of hydrogen sulfide in preventing mitochondrial damage.

Shopping is 'throwback to days of cavewomen'↗ | *Ben Leach, The Telegraph*
This article connects modern shopping behaviors to evolutionary psychology concepts.

The Limits of "Grit" ↗ | *David Denby, The New Yorker*
This article reviews literature on grit as a predictor for success.

# 04 | Science Education

## **Informal Science Education 101** | Module

This module provides practical and theoretical tools to deepen youth understanding of Informal Science Education (ISE) pedagogy and strengthen their practice as educators.

**Goal #1** **Deepen youth understanding of ISE philosophy and pedagogy.**

- Invite youth to read and discuss reports, theoretical frameworks, opinion pieces, and other media related to informal science learning. During TSRCP piloting, mentors used a range of short articles, book chapters, and webinar recordings with youth (see **Informal Science Education Resources**).
- Encourage youth to reflect on their own experiences in formal and informal education settings. What experiences have they had that helped them feel supported as learners? What experiences have they had that they didn't feel were supportive of their learning?
- Connect youth with ISE professionals (see **Community Connection Chats**). During TSRCP piloting, mentors hosted professionals virtually over Zoom, as well as in-person.
- Invite youth to participate in and learn from field-wide professional networks. During TSRCP piloting, youth engaged with professional networks (e.g., ASTC, NEMA, AAM) through online forum boards, webinars, and in-person conference convenings.

**Goal #2** **Build youth skills and confidence as educators.**

- Provide youth with opportunities to shadow and learn from near-peer and expert educators.
- Create safe spaces for youth to practice new skills or competencies with mentors and one another. During TSRCP piloting, youth frequently held "dry runs" of meetings or programs, where familiar staff would take on different imagined roles (e.g., visitor, stakeholder, evaluator).
- Host regular check in meetings with youth that encourage thoughtful reflection on educational strengths and opportunities for growth. During TSRCP piloting, youth engaged in a monthly

one-on-one check in with both mentors (see **Youth Check In Template**).

- Lead skill-based workshops and trainings that build youth capacity as educators across contexts (see **Science Is An Activity**, **Facilitation Strategies**, and **Learning Across Modalities**).

**Goal #3**

**Familiarize youth with a range of informal science and other educational tools.**

- Send youth on a scavenger hunt to look for evidence of learning in action, using specific frameworks or tools as a pedagogical lens. During TSRCP piloting, mentors encouraged youth to look for design attributes using tools that drew on the Museum of Science's *Science is An Activity* framework for exhibitions (see ***Appendix***: "Science Process Skill Wheel"), as well as strategies described by the Exploratorium's *Exhibit Designs for Girls' Engagement* project, and approaches described in *The Constructivist Museum* (see **Resources**, below).
- Highlight exemplar research studies that have practical applications for ISE organizations. For example, many *Living Laboratory Research Toys* (see **Resources**, below) highlight classic child development research studies that have informed pedagogy (e.g., growth and fixed mindsets).

**Resources**

Exhibit Designs for Girls' Engagement: A Guide to the EDGE Design Attributes↗ | *Dancstep & Sindorf, Exploratorium*
This website provides an evidence-based overview of exhibit design attributes that support girls' engagement.

The Constructivist Museum↗ | *George Hein*
This article proposes a model for museum educational theory framed around epistemological and learning philosophies.

Living Laboratory Research Toys↗ | *National Living Laboratory Initiative*
This webpage includes research articles and interpretation guides for a number of classic child development studies.

## **Science Is an Activity** | Activity Guide

This guide presents is one approach for engaging youth in learning about science process skills and supporting youth to on their own practice as educators.

**Estimated Time:**

- 60 minutes

**Materials Needed:**

- Science Process Skill Wheel (see ***Appendix***)
- Science Process Skill Bingo Cards (see ***Appendix***)
- 20-30 small objects (e.g., beans, buttons, coins) per youth
- Writing instruments

**Activity Outline**

| | |
|---|---|
| **Brainstorm** | Science process skills are the cognitive, physical, and social skills that learners practice and develop when doing science. These skills are the fundamental elements that allow someone to engage in the scientific process. Invite youth to brainstorm different skills they use when doing science. |
| **Explore** | Ask youth to spend ~2-3 minutes playing with and exploring a set of small objects (e.g., beans, shells, buttons) in any way that they want - this can happen solo or in small groups. Encourage them to think about what they are doing with the objects, and anything they are noticing as they explore. |
| **Notice Skills** | Share the Science Process Skill wheel and ask youth if they notice any skills on the wheel that they practiced as they played with the objects. This framework highlights categories of science process skills and related actions - youth may find it helpful to review and define certain terms as a group. |
| **Play Bingo** | Provide each individual (or group) with a bingo card that matches the skills on the Science Process Skill wheel. On the bingo card, each square represents an action or activity that learners can engage in to develop their science process skills.<br><br>Play Science Process Skill bingo! Instruct youth to choose a word to start with. As they complete that action, they can cross out, highlight, or otherwise mark that square. To gamify the experience, challenge youth to get five in a row |

| | |
|---|---|
| | (diagonal, vertical, or horizontal). If youth get BINGO, call it out! Then, invite each group to reflect on the actions they took to complete each square |
| **Debrief** | Lead a group discussion and reflection about where youth see science process skills used in practice - at the institution, when engaged in science research, or at their schools. |
| **Scavenger Hunt** | If possible, send youth on a scavenger hunt to find examples of science process skills in practice (e.g., at exhibit experiences, at home, in their practice). |

## **Learning Across Modalities** | Discussion Guide

This guide shares strategies for engaging youth in discussion and reflection about different modalities for science learning.

**Watch video**

As a group, watch and discuss the TEDx talk "Learning styles & the importance of critical self-reflection↗" (Tesia Marshik), which highlights research on the concept of learning styles. This video argues that while learners may prefer specific learning modalities (visual, auditory, tactile, kinesthetic), one modality is not more effective than any other for their conceptual learning.

**Guiding Questions**

Guide youths' reflections by encouraging them to consider the following questions:

- How do the ideas shared in this video relate to what you already know?
- What do the ideas shared in this video make you wonder?
- Do you have a preferred learning modality?
- Do you see any applications from this video for your own learning experiences?

**Discuss**

What does this look like in practice?

In educational settings, more than one learning modality is often activated at the same time in order to support a range of learning preferences and enhance the educational experience of all learners. In the video, the speaker shares an example about using several different modalities to learn about the different parts of a symphony orchestra. Encourage youth to recall any learning experiences they've had where multiple learning modalities were employed (effectively, or otherwise!)

How does this information impact our teaching?

Invite youth (as individuals, or in pairs) to pick an exhibit, program, or other educational activity, and brainstorm strategies for incorporating additional learning modalities into the learning experience. Youth may find it helpful to begin by discussing general features of a particular learning modality as a group; the **Learning Across Modalities Tool** can be used to help kickstart this conversation.

## **Learning Across Modalities Tool** | Worksheet

**Consider:**

- What are some general features of the following learning modalities?
- Are there other learning modalities you use that are not included here?

| **Visual** | **Auditory** |
|---|---|
| Information you can see or read (e.g., labels, books)<br><br>Colorful illustrations & pictures; graphs or diagrams<br><br>Visual comparisons (similarities and differences) | Information you can hear or listen to (e.g., lectures, music)<br><br>Discussion & engaging in dialogue<br><br>Oral instructions |
| **Kinesthetic** | **Tactile** |
| Movement & physical activity<br><br>Demonstration<br><br>Role playing and dramatic play | Hands-on experiences<br><br>Manipulable materials<br><br>Writing, tracing, drawing, building |

## **Youth Equity Pause** | Discussion Guide

This discussion guide focuses on engaging youth in reflective noticing of DEAIB across their work.

Engaging in regular "Equity Pauses" centers DEAIB (Diversity, Equity, Access, Inclusion, and Belonging) in youth's practice and ensures that conversations about equity are ongoing and prioritized in youth's experiences.

The Y*outh Equity in STEM (YESTEM) Equity Compass* framework (see **Resources**, below) describes eight dimensions of equity:

1. Power
2. Time
3. Resources
4. Participation
5. Centrality
6. Orientation
7. Approach
8. Interests

During TSRCP piloting, youth engaged in nine equity pause discussions: one for each of the eight dimensions, and a final reflection and debrief. This guide is intended to be re-used for each of the eight dimension discussions. During TSRCP piloting, Equity Pauses were held approximately once a week, but the frequency varied with youth's project timelines and the nature of the other work they were engaged with at any time.

**Introduce the Equity Pause Discussion Framework**

Begin the Equity Pause dialogue by co-creating a set of discussion agreements, to ensure all participants are speaking and listening from a place of mutual respect and appreciation for one another's thoughts and experiences. The *NISENet Forums Manual* provides suggestions for facilitating this process (see **Resources**, below).

Invite youth to reflect on an experience they have had that made them feel welcomed (or not) in STEM. Offer the option for youth to share their stories with a peer or keep it to themselves. The intent of an Equity Pause is to ensure that *everyone* feels welcomed in STEM, by reflecting on existing equity gaps in one's work, identifying strategies to act on growth opportunities, and celebrating DEAIB strengths.

Introduce the *YESTEM Equity Compass*, discuss the intention of the framework, and share how it will be used in future Equity Pauses to drive reflection and discussion. Come to a group agreement on the schedule and expectations for this equity work.

**Ongoing Asynchronous Reflection**

To kick off each dimension-specific Equity Pause, review the definition of that dimension, as well as the guiding questions included in the *YESTEM Equity Compass* as a group. Invite youth to add their own definitions to the dimension or contextualize the existing description within their own knowledge and experiences.

Provide youth with time to asynchronously reflect on how the dimension emerges in their work between this and the following Equity Pause. Encourage youth to think about and document:

- Are there any projects they are working on that they feel are reproducing existing inequitable structures?
- Are there any projects they are working on that they feel are driven by equitable processes?
- Are there any projects they are working on, where they aren't sure how that particular dimension might be embedded?
- Where along the equity compass (inner to outer segment) do they see their work aligning?
- Do they see any opportunities for themselves to act as equity advocates for that dimension?

If time allows, print out a large version of the equity compass, and encourage youth to document their thoughts on sticky notes and attach these to the dimension of interest.

**Equity Pause Debrief**

Once youth have had opportunities to reflect across each dimension of the YESTEM equity framework, come together as a group to debrief. If youth have documented their reflections in some way (e.g., through sticky notes, journaling, a worksheet), invite them to share their thoughts as they are comfortable across each dimension, and on the Equity Pause process as a whole.

An important step in the YESTEM framework is to move from reflection to action. Youth may have suggestions for things to stop doing, things to start doing, and practices to change. When youth suggestions fall within the mentors' scope for making change, discuss together about what decisions or actions can be taken and why. When youth suggestions fall outside the mentors' scope, ensure there is clear communication about any processes or follow up that can happen. To support action-oriented work, mentors might:

- Reach out to the appropriate institutional personnel and invite them to meet with youth. For example, during TSRCP piloting, youth met with a member of the Museum's bilingual offerings team to discuss an interest in creating "I speak…" pins to indicate to visitors the language(s) an educator speaks.

- Invite a colleague who worked on a similar equity challenge to share that story with the youth. For example, during TSRCP piloting, youth spoke with a researcher about their challenges in recruiting a diverse audience for their study, and the steps they took toward solving that problem.
- Introduce youth to affinity groups directed toward similar equity goals. For example, during TSRCP piloting, several youth joined an informal lunch group aimed at welcoming new staff with shared cultural backgrounds.

**Resources**

NISENet Forums Manual↗ (pg 20 - 23) | *NISENet*
This document provides suggestions for establishing effective small group dialogue.

Youth Equity in STEM (YESTEM) Equity Compass↗ | *Youth Equity in STEM*
This site provides an introduction to the equity compass framework, and shares resources and other materials for engaging in reflection and action.

## **Informal Science Education Resources** | Resource List

This resource list includes a variety of practical and theoretical literature on Informal STEM Education.

**Links**

Designing for Productive Struggle: A Research and Development Guide to Creating Exhibits that are Both Challenging and Rewarding↗ | *Museum of Science, Boston*
This guide offers exhibit design strategies that support learners to feel both challenged and satisfied by an experience.

Exhibit Designs for Girls' Engagement: A Guide to the EDGE Design Attributes↗ | *Dancstep & Sindorf (Exploratorium)*
This website provides an evidence-based overview of exhibit design attributes that support girls' engagement.

Learning Science in Informal Environments: People, Places, and Pursuits↗ | *National Research Council*
This book shares an organizing framework that synthesizes literature and knowledge on informal science learning.

Next Generation Science Standards↗ | *National Academies Press*
This framework defines critical dimensions of science learning for K-12 students and establishes appropriate learning standards for each grade level.

The Constructivist Museum↗ | *George Hein*
This article proposes a model for museum educational theory framed around epistemological and learning philosophies.

Universal Design Plan↗ | *Museum of Science, Boston*
The report on this webpage shares concrete design and development strategies that support a range of learners' needs.

Universal Design for Learning Guidelines Graphic↗ | *CAST*
This graphic organizer shares guidelines for supporting learners with a range of cognitive and social-emotional needs and preferences.

Visual Thinking Strategies↗ (VTS) | *Abigail Housen & Philip Yenawine*
This framework provides educators with facilitation methods for critical observation and reasoning.

## **Understanding Audiences** | Module

This module supports youth to consider the underlying agendas that inform visitor behaviors, and trains youth in educational strategies for supporting different visitor groups.

**Goal #1** **Encourage youth to reflect on the circumstances, motivations, and agendas that bring people to an experience, and how this impacts their behavior.**

- When available, share institutional data about visitor motivations. Encourage youth to reflect on how a group learned about the institution, what made them decide to visit, what they decided to do once onsite. During TSRCP piloting, youth previewed and reflected on visitor exit survey data sourced from *COVES* (see **Resources**, below).
- Invite youth to share their own museum agendas in a round robin discussion. What makes them decide to visit a museum or other cultural experience? Who do they visit with, and how does this impact what they see or do? What museum experience has been their favorite, and why?
- Play a perspective taking game, in which youth take on the role of different visitors to the Museum. During TSRCP piloting, youth played a game from the *Learning Together: Families in Museums Staff Training Curriculum* developed by the Boston Children's Museum (see **Resources**, below).

**Goal #2** **Engage youth in discussion about strategies to support visitor learning across a wide range of motivations.**

- Brainstorm facilitation strategies as a group and consider how they may be applied with different kinds of learners. During TSRCP piloting, youth played an Apples to Apples© style game modified from materials developed at the Children's Museum of Pittsburgh (see **Facilitation Strategies**).
- Explore pedagogical frameworks from across informal education platforms. During TSRCP piloting, youth engaged in training and read excerpts from theoretical publications on pedagogy (see **Informal Science Education Resources**).

**Goal #3**

## Build youth competency in science interpretation

- Leverage cross-departmental staff expertise to engage youth in on-the-floor training with visitors. During TSRCP piloting, youth trained as educators across several departments with front-line staff, learning to interpret in an early childhood exhibit, an engineering exhibit, and a human biology exhibit.
- Train youth in specific educational activities, programs, or other hands-on visitor experiences (see **Interpretation Guide: Copter Engineering** for an example).
- Supplement on-the-floor experience with trainings and other practicums designed to familiarize youth with developmentally appropriate facilitation strategies

**Resources**

COVES Website↗ | *Collaboration for Ongoing Visitor Experience Studies*
COVES, or the Collaboration for Ongoing Visitor Experience Studies, is a cross-institutional project which seeks to better understand visitor demographics, motivations, and experiences.

Learning Together: Families in Museums Staff Training Curriculum↗ (pg. 77-80) | *Boston Children's Museum*
This resource was modified to develop an activity that encouraged youth staff to consider how visitor motivations are influenced by experiences that extend outside the walls of the institution.

## **Facilitation Strategies** | Activity Guide

This activity engages youth in an Apples-to-Apples style game about facilitation strategies to engage Museum visitors, providing youth with practical tools for interpretation in a way that is responsive to visitor behaviors and needs.

This activity draws inspiration and materials from the Children's Museum of Pittsburgh "Facilitating Learning through Making" project.

**Estimated Time:**

- 30 minutes

**Materials Needed:**

- Printable Visitor Type Cards (see ***Appendix***)
- Printable Facilitation Strategy Cards (see ***Appendix***)

### Activity Outline

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|---|---|
| **Reflect** | Visitors come to the Museum with a range of motivations, interests, lived experiences, and perspectives. All of these considerations and more may impact their behavior when they visit, as well as their motivations for how they engage.<br><br>Invite youth to consider, "What kind of Museum-goer are you?" Encourage them to think about what they do (or don't do) when visiting a museum experience, and what drives that behavior. |
| **Card Game** | Begin the card game! Deal 6 random Facilitation Strategy cards to each player - they can look at their own cards but should hide them from others.<br><br>Select a Visitor Type card and read it aloud to everyone. Explain the goal of the game to players - to pick the facilitation strategy that they think will best support that visitor.<br><br>Invite each player to pick one Facilitation Strategy card and place it on the table face down.<br><br>Reveal all cards at the same time; invite youth to share their rationale for selecting a Facilitation Strategy card, and how they think it will support the Visitor Type card to engage. Note: Unlike Apples-to-Apples, the dealer doesn't pick a "best" Facilitation Strategy card in this game; sometimes many different strategies (on their own, or in combination) may support a visitor's engagement! |

| | |
|---|---|
| **Repeat** | Discard the used Facilitation Strategy cards and invite a new person to be the dealer.<br><br>The new dealer should hand out one additional Facilitation Strategy card to each player and pick a Visitor Type card to start the next round. |
| **Discuss** | Groups can play as many or as few rounds as desired! You may find it valuable to also discuss cards players *didn't* pick and why - this can lead to some very insightful reflections! |
| **Resources** | Learner's Behavior Professional Development Card Deck↗ \| *Children's Museum of Pittsburgh, Carnegie Mellon University*<br>This card game encourages educators to consider how different facilitation strategies may be applied to support different kinds of learners in a maker setting. |

## **Designing with Accessibility in Mind** | Activity Guide

This activity is a modified scavenger hunt. It introduces strategies for meeting the physical, cognitive, social-emotional, and cultural needs of all learners to ensure experiences are welcoming and accessible for everyone.

**Estimated Time:**

- 60 - 75 minutes

**Materials Needed:**

- Universal Design Persona Cards (see ***Appendix***)
- *Museum of Science Universal Design Plan* (see **Resources**, below)
- *Universal Design for Learning Guidelines Graphic* (see **Resources**, below)

### Activity Outline

**Introduce**

Creating welcoming, educational, and meaningful experiences for all learners means educators must carefully consider the supports that will meet the accessibility needs and preferences of everyone. Invite youth to discuss what they think "accessibility" means, and why educators care about this topic.

Define Universal Design (UD; guidelines for making an experience comfortable for the widest range of people) and Universal Design for Learning (UDL; guidelines for supporting learning for the broadest range of people) with youth. Share the Museum of Science *Universal Design Plan* and the *Universal Design for Learning Guidelines Graphic*, and discuss:

- Are there any features that feel familiar to you? Any features that are unfamiliar?
- Do any of these guidelines surprise you?
- Have you seen any of these guidelines in practice before?

**Discuss**

Reflect on the example of using a "curb cut" (an accessibility change that was innovated for one group that ultimately improved experiences across many groups). Curb cuts get their name from the sidewalk feature that slopes down from the edge of the sidewalk to the street—literally, a curb cut! Brainstorm what groups of people may benefit from the addition of a curb cut in a sidewalk. Youth may find it engaging to discuss additional examples of design choices that support universal access (e.g., open captioning, icons paired with words).

**Scavenger Hunt**

To get a better sense of how these principles can be integrated within an informal learning environment, send youth on a scavenger hunt to find specific accessible design features that suit different needs or preferences. In pairs or small groups, provide youth with a Universal Design Persona card, and encourage them to seek out exhibits, activities, or programs that incorporate the design guidelines from the UD and UDL resources to support that persona.

Once youth return, debrief as a group about the design features they found. Were there any supports that were not present, or hard to find? Were there any features present in the museum that they hadn't noticed previously?

**Brainstorm**

Encourage youth to think about an activity that they facilitate as educators (see **Interpretation Guide: Copter Engineering** for an example).

Using their same Universal Design Persona card, encourage youth to brainstorm facilitation strategies they might use (or already use!) to support that learner's needs or preferences. As a full group, consider how each facilitation strategy that youth identified might support a broader range of learners by sharing ideas about who else could benefit from that strategy. Make connections back to UD and UDL principles as youth discuss their facilitation strategies.

**Resources**

Universal Design Plan↗ | *Museum of Science, Boston*
The report on this webpage shares concrete design and development strategies that support a range of learners' needs. The link to "Accessibility Resources for Visitors" directs users to a webpage with MOS-specific accessibility accommodations.

Universal Design for Learning Guidelines Graphic↗ | *CAST*
This graphic organizer shares guidelines for supporting learners with a range of cognitive and social-emotional needs and preferences.

## **Museum Interpretation** | Module

This module deepens youth's skills as educators and offers opportunities for youth to apply those skills to novel work.

**Goal #1** **Support youth to develop or refine an interpretation activity.**

- Share existing activity structures, development frameworks, or other documentation with youth to provide a starting point for organizing their thoughts. During TSCRP piloting, youth used **Developing an Interpretation Guide** to organize their work.
- Lead dialogues in which youth can reflect on their perspectives on a topic. During TSRCP piloting, youth kicked off the development of a new activity focused on artificial intelligence (AI) by brainstorming where these technologies are used in daily life and discussing AI topics that mattered to them (see **Youth Projects: Examples from TSRCP Piloting**).
- Leverage youths' on-going training in science research to support activity development. For example, familiarity with reading research articles can support youth to gain knowledge about the science content or concepts related to an activity.
- Leverage youths' on-going training in evaluation methods to support activity development. For example, to understand visitors' prior knowledge related to the AI activity, youth developed and led a front-end evaluation study on visitors' existing perceptions of AI technology.
- Provide opportunities for youth to solicit visitor and staff feedback. Coordinate prototyping opportunities for youth, as well as connection opportunities to get suggestions from knowledgeable educators.

**Goal #2** **Support youth to gain proficiency in interpretation through repeated opportunities to extend their skills.**

- Provide opportunities for youth to continue building the repertoire of activities they can choose to present, and therefore the specific science content they are comfortable discussing with others.
- Provide opportunities for youth to work with different audiences, or to work in new environments. For example, invite youth to participate in hosting groups of peers from other organizations, or to facilitate activities outside of the museum (e.g., at community organizations or events).
- Leverage youths' ongoing training in science education practices to support the development and prototyping of new interpretations, hands-on activities or exhibitions. During TSRCP piloting, youth provided advisership to project teams, brainstormed experiential goals, and prototyped new activities and interactives with the public.

## **Interpretation Guide: Copter Engineering** | Activity Guide

This guide describes an engineering activity that youth can facilitate with museum visitors. The structure of the activity offers youth an example of the ways science education practice works to integrate content background and knowledge of developmental stages to facilitate learning in ways that are meaningful and developmentally appropriate for many different learners.

**Materials Needed:**

- Printable Copter Patterns (see ***Appendix***)
- Paper Clips
- Scissors
- Several pre-crafted Copter examples

The copter engineering activity encourages young children to (1) create and test a prototype, (2) to set a goal for creating a more effective design, and (3) to change one variable at a time in controlled experiments to make their copter meet their goal.

We restrict the types of materials that are available to foster creative problem solving as children test, change, and re-test their designs. As educators, youth can help visitors use the tools and materials available for the activity in ways that are safe and appropriate for their age, while introducing them to the scientific of air resistance and push.

### Youth educators will:

| | |
|---|---|
| **Ask visitors questions** | ○ What materials do you need to make a copter?<br>○ Are you ready to test it out?<br>○ What happens as it falls?<br>○ Which way does it spin?<br>○ What happens when you change the wing's shape, weight, or size?<br>○ Are you ready to try your new design? |
| **Support visitors to make a copter** | ○ Show visitors examples of copters that have already been made.<br>○ Ask visitors to identify some differences between the different copters (e.g., size, wing shape, number of paperclips, etc.). |

- Help young visitors with cutting, folding and paper clipping skills (but let them do as much as possible).
  - Help with cutting: try holding one side of the paper and guide them as they line up scissors on the other side.
  - Help with folding: try doing a loose fold, then invite them to press down and smooth the crease.
  - Help with paper clipping: try inviting them to hold the paper and watch while you add the clip; or, offer to hold the paper while they maneuver the clip. Sometimes, comparing an open paperclip to a mouth (like an alligator!) can help with orientation of the materials. Some kids might learn how to use a paperclip on their own, if you demonstrate first, then remove the paper clip, and invite them to try for themself.

**Encourage visitors to complete multiple tests and/or re-design**

- Can you make your copter spin in a different direction?
- What else can you change about your copter?
- Now how does it spin?
- Can you make one that spins more quickly (or slowly)?

**Share the Science and Engineering Background**

When the copter falls, air pushes up against the blades, bending them up just a little. When air pushes upward on the slanted blade, some of that thrust becomes a sideways, or horizontal, push.

The two blades are each getting the same push, but in opposite directions. The two opposing thrusts work together to cause the copter to spin. Educators can challenge visitors to make the copter spin in the opposite direction by changing the direction of the pushes.

**Support developmentally appropriate skill-building**

**What can an infant do today?**

- Some very young children are still in a developmental stage where they use their mouths to “test” everything and will need their grownup’s close guidance to participate. Many infants enjoy watching copters fall and spin.

**What can a toddler do today?**

- Observe: Toddlers can touch the paper and paperclips and think about what these materials are usually used for. They can answer questions about the copter such as “What did it do?” or point to the copter as it spins or track it with their eyes.
- Classify: Toddlers can point or verbally answer classification questions such as “What shape is this?” and “Which one is bigger?”

- Use Tools: Children at this age enjoy working with scissors and typically use a two-handed grasp. Adults can help them by steadying the paper for them as they cut.
- Set goals: Dropping their copters helps younger toddlers practice their raking grasp. It may be difficult for them to release their copter at will and they may throw it rather than drop it.

**What can a pre-school visitor do today?**

Preschoolers can benefit from all of the activities that a toddler can do, as well as those listed here.

- Observe: Preschoolers notice that differently shaped and sized copters fall at different speeds.
- Set goals: Preschoolers show interest in what their peers are doing and making. They may design their copters based on the choices they see others making. They continue to develop the systematic controlled release and may be able to release two copters (one from each hand) at a time.
- Use tools: They can use scissors with greater mastery than a toddler and are able to cut more intricate patterns. They can be encouraged to use a more traditional (one-handed) grip on the scissors. Some preschoolers can use paperclips especially after watching a grown-up demonstrate.

**What can an early elementary aged visitor do today?**

Early elementary aged children can benefit from all of the activities that a toddler or preschooler can do, as well as those listed here.

- *Observe and conclude:* Early elementary aged visitors can see connections between the design they build and the results they get. They can draw conclusions based on their observations.
- *Hypothesize:* Early elementary aged visitors can try to guess which of two copters will fall the fastest.
- *Use Tools*: Early elementary aged visitors are adept at scissoring. They also have developed the fine motor skills necessary to use paperclips. Some may know how already, but others may need the volunteer to demonstrate it for them. They also begin to understand how time is measured and can practice using the stopwatch to time their results.
- *Act Cooperatively:* Early elementary school children might compare their results to their peers, or challenge peers to a race. They have no difficulty performing a controlled release of their copter and can participate in races.

- *Plan and design:* Early elementary school children can make their own wing designs.

**What can an adult visitor do today?**

Adults can benefit from doing all of the activities that children do, in addition to those listed here.

- *Scaffold:* Adults can help young children as they assemble their copters, but it is important for adults to remember that children benefit most when they are allowed to complete as many of the steps of making the copters as their age and level of development permits. A child is better served by having an adult show him how to use a paper clip (and then backing up so the child can have a try) than by having an adult simply do it for him.
- *Make their own:* Adults are always welcome to make their own copter and experiment with it!

**Resources**

Leif Catches the Wind↗ | *Engineering is Elementary*
This children's book tells the story of a character, Leif, who solves an engineering problem by designing a windmill for his friend.

## **Developing an Interpretation Guide** | Worksheet

Educators can use this annotated organizer to document the critical components of an interpretation guide when developing a new activity.

| | |
|---|---|
| **Introduction** | Broadly describe what visitors will do during the activity. Define the activity's learning goals (what knowledge, skills, or attitudes visitors will take away from the activity). |
| **Guiding Questions** | Craft questions that will serve to guide educators and adult visitors facilitating the activity with children. |
| **Materials List** | List the objects, tools, documents, and consumables that are needed to run the activity. It may be useful to include photographs of the activity set up. |
| **Activity Instructions** | Provide basic instructions for educators to facilitate the activity. Suggest questions and techniques for educators to try if they get stumped in an interaction or need a place to start. |

| | |
|---|---|
| **Science or Engineering Background** | Provide an overview of the content that will support educators to achieve the learning goals of the activity. This may include:<br><br>o Important STEM concepts to communicate with visitors<br>o Definitions of any vocabulary or jargon<br>o Skills or actions that scientists who study this topic might use<br>o Resources for educators to learn more |
| **Science Process Skills** | Describe how the activity can be scaffolded to meet the physical and cognitive needs of visitors at different ages. Describe the developmentally appropriate science skills (e.g. observe, classify, experiment, use sense, make models) and engineering practices (e.g. set goals, create-test-recreate, use tools, manipulate materials, act cooperatively) that visitors will engage in while participating in the activity. Subsections may include:<br><br>o What can an infant do today?<br>o What can a toddler do today?<br>o What can a preschool-aged visitor do today?<br>o What can an early elementary-aged visitor do today?<br>o What can an adult do today? |

# 05 | Program Evaluation

# Evaluation Tools and Considerations for Evaluators

## Evaluation Tools

This section provides method recommendations and instruments for evaluating youth programs similar to TSRCP. These instruments are designed to study changes in youths' science identity in terms of their interest in and affinity for STEM; their skills and self-efficacy around research, communication, and education skills; and their sense of belonging in STEM communities.

Drawn from the TSRCP piloting effort, the surveys and interview protocols were designed to evaluate a year-long program with a dedicated evaluation team. Recognizing the varying capacity and needs of organizations to conduct such intensive studies, this section also presents considerations for adapting the instruments to local program needs.

**Survey**

The survey included in this toolkit takes approximately 5 minutes to complete. In general, youth were asked the same questions throughout the evaluation to measure change over time, with some questions only appearing on the pre-survey and others needing language adjusted to reflect where youth are in the program (e.g., "what *are* the most interesting" versus "what *were* the most interesting"). Instruments have annotations in brackets about the language adaptations, as well as which check-in point(s) each question was used for.

**Interviews**

Two interviews are included in this toolkit, one that pairs with the pre-survey and one that pairs with either the mid- or post-survey; each takes approximately 20-25 min to complete. The interviews are designed to incorporate member-checking in which participants reflecting on their own survey responses; the bracketed text indicates the survey question the interview is referencing and/or a placeholder for the participant's response. Ideally, visual representations of the participant's previous survey responses would be created prior to each mid- or post-interviews, providing a reference of their data for participant reflection.

## Considerations for Evaluators

The evaluation instruments in this toolkit are drawn from a feasibility study that supported an embedded evaluation protocol. In this study, youth participants contributed data at four points throughout a year-long program, completing a survey followed by an interview at each point. The evaluation relied on rich qualitative data from interviews to support meaning-making with survey data and incorporated member checking at each stage through the interview. While the protocol produced data that offered a nuanced understanding of youths' experiences with the program, the number of check-ins, amount of survey data, and level of qualitative analysis were time consuming and resources for this level of work may not be available for all projects.

Below are suggestions for modifying and using the instruments:

**Full evaluation protocol**

Collect survey and interview data at least three times during the program. The pre-survey and interview should be administered before the program (e.g., during youth onboarding), while the post-survey and interview should be administered as the program wraps up or directly after it ends. The mid-survey should take place roughly in the middle of the program or between major inflections in the focus of youth's work.

The **Meaning Mapping Activity** can be integrated into the pre- and post-interview, allowing evaluators to assess change over the course of the program, or completed separately and analyzed as a program artifact.

**Adjusting the number of data points**

The length of the program and availability of evaluation capacity will impact which data are collected and how often. The full protocol involves three check-in points (pre, mid, post) that include a survey and follow-up interview. The protocol could be adjusted to collect only survey data and not interview the youth at all, or to only interview youth at the end of the program. The mid check-in point may be repeated at multiple points for a longer program or removed entirely, depending on how much opportunity there may be for the program team to adjust their approaches during the program period.

*Without substantial modifications to the protocol or instruments, the minimum data needed to understand the impacts of the program can be drawn from a pre- and a post-survey.*

**Involve youth as evaluators of their experience**

Programs that train youth in research skills may be able to engage youth in evaluation activities in ways that support youth's self-reflection and research skill development while also providing useful information for project teams to make improvements. For example, program implementation teams could administer the survey at regular intervals during the program, then involve youth in analyzing and making meaning of their own data. Or, the interview instrument could be adapted as a youth-led focus group, where the youth collaboratively report on what they feel is effective and generate recommendations for the program implementation team.

**Modifying questions or items from the instruments**

Not all programs can provide the full range of experiences offered to youth in the TSRCP piloting effort. In these cases, the evaluation tools can be adjusted by removing questions or items from the instruments that are not relevant to the program context. Evaluators might choose to include fewer items within a survey question, or to use questions that focus on just one aspect of science identity.

Depending on program context, the interview questions could be used as journal prompts, supporting youth to record and consider their own reflections on program experiences.

For more information about the studies these instruments were drawn from, please refer to the evaluation reports referenced below. Each report focuses on one of two youth cohorts involved in the piloting effort. These reports include detailed descriptions of the methods, detailed findings, individual case studies, and the original instruments. The Discussion section of the *Cohort 2 Evaluation Report* addresses overall reflections on the piloting effort and offers recommendations for future research.

**Resources**

- Todd, K. & Weitzman, O. (2021). Cohort 1 Evaluation Report↗. Museum of Science, Boston. This report highlights the evaluation findings from the first cohort of TSRCP piloting.
- Anderson, A & Todd, K. (2023). Cohort 2 Evaluation Report↗. Museum of Science, Boston. This report highlights the evaluation findings from the first cohort of TSRCP piloting.

**Survey** | Evaluation Tool

1. **Which aspects of the program [are/were] most interesting to you?** (Select up to 3)

☐ Doing scientific research
☐ Doing science communication
☐ Doing science education
☐ Being mentored by STEM professionals
☐ Being a part of the museum community
☐ Being a part of the university community

2. **Please indicate how much you disagree or agree with the following statements,** from strongly disagree (1) to strongly agree (9).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Scientific topics interest me. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am interested in reading websites, articles, or books about scientific issues. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am interested in pursuing a degree in a scientific field in college or graduate school. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I know a lot about science. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Science is relevant to my daily life. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

3. **When I think about science, I tend to feel...** (check all that apply)

☐ Bored ☐ Confused ☐ Content ☐ Curious ☐ Excited ☐ Frustrated
☐ Grateful ☐ Humble ☐ Included ☐ Inspired ☐ Lonely ☐ Nervous
☐ Proud ☐ Sad ☐ Satisfied ☐ Tense ☐ Unsure

**4. [Pre-only] What scientific skills do you most want to develop as a part of this program?** (select up to 3)

- ☐ Reading papers written by scientists
- ☐ Developing a research question
- ☐ Considering the ethics of a research study
- ☐ Collecting data
- ☐ Writing up a study for a scientific audience
- ☐ Using statistical software to visualize data
- ☐ Talking about scientific methods with the public
- ☐ Presenting and discussing my research with academic audiences
- ☐ Making sense of data
- ☐ Writing a popular press piece about a scientific topic
- ☐ Evaluating the strengths and weaknesses of scientific arguments
- ☐ Evaluating the effectiveness of science communication
- ☐ Connecting research to museum practice and design
- ☐ Iterating on the research questions and methods of prior research studies
- ☐ Conducting statistical analyses
- ☐ Other (please describe): _____

**5. How confident are you in your ability to do the following science research skills?** Please respond on a scale from not at all confident (1) to extremely confident (9).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Reading papers written by scientists | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Considering the ethics of a research study | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Iterating on the research questions and methods of prior research studies | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Developing a research question | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Using statistical software to visualize data | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Collecting data | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Conducting statistical analyses | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Making sense of data | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: _____ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

6. **How confident are you in your ability to do the following science education and science communication skills?** Please respond on a scale from not at all confident (1) to extremely confident (9).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Evaluating the strengths and weaknesses of scientific arguments | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Writing up a study for a scientific audience | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Talking about scientific methods with the public | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Presenting and discussing my research with academic audiences | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Connecting research to museum practice and design | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Writing a popular press piece about a scientific topic | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Evaluating the effectiveness of science communication | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: _____ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

7. **Please indicate how much you disagree or agree with the following statements, from** strongly disagree (1) to strongly agree (9).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| I am a scientist | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am a science educator | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am a science communicator | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am a member of the museum community | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am a member of the university community | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**8. [Pre-only] Please indicate how much you disagree or agree with the following statements**, from strongly disagree (1) to strongly agree (9)**.**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| I have experience working with children in professional and/or educational contexts. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I am familiar with psychology or psychology research. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| I would like to have a job that uses science. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| People who are like me, work in science. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| My parent(s)/guardian(s) know a lot about science. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

## Pre-Interview

The interview is designed to incorporate member-checking through participants reflecting on their own survey responses, so bracketed text indicates the survey question the interview is referencing and/or a placeholder for the participant's response.

### Youths' Background and Prior Experience

1. What has science been like for you in your classroom education to date?
2. What have you found particularly interesting or disinteresting about science in classroom settings?
3. What types of science-related things have you done outside of classrooms, if any?
4. What have you found particularly interesting or disinteresting about those out-of-school science experiences?
    a. Probe: Do other people think you're good at science outside of the classroom? Why do you think so?
    b. Probe: You said on your survey **[the participant's response for the statement in question #8, "My parent(s)/guardian(s) know a lot about science"]** that your parent/guardian knew a lot about science. Could you explain that?

### Interest

5. On the most recent survey that you completed, you said in response to the question, "Which aspects of the program are most interesting to you?" that **[participant's response to survey question]** were the most interesting aspects of the program for you. Can you tell me what you find interesting about them?
6. On your survey you said you tend to feel **[participant's response to the question, "When I think about science, I tend to feel…"]** when you do science. Why do you feel that way?

### Self-Efficacy

7. On your survey, you said that you were **[most confident]** in **[1-2 highest rated response from the question, "How confident are you in your ability to do the following science research skills?"]**. Why did you give that rating?

8. You said you were **[least confident]** in **[1-2 lowest rated response from the question, "How confident are you in your ability to do the following science education and science communication skills?"]**. Could you explain why you felt that way?

9. On your survey, you said that you were **[most confident]** in **[1-2 highest rated response from the question, "How confident are you in your ability to do the following science education and science communication skills?"]**. Why did you give that rating?

10. You said you were **[least confident]** in **[1-2 lowest rated response from the question, "How confident are you in your ability to do the following science research skills?"]**. Could you explain why you felt that way?

## Belonging and Recognition

11. On your survey you indicated **[level of agreement from participant's response to question #7]** that you were a **["scientist", "science educator", and "science communicator"]**. Could you describe your identity in relation to science, science education, and science communication?

12. On your survey you **[level of agreement from participant's response to question #8]** that you would like to have a job that uses science. What, if any, are your plans for after high school?

## General Feedback

13. **[Include when evaluation starts after the program]** In future interviews, if you choose to participate, we will ask questions about how the program is going. We know things just started, but so far, how would you say things are going?

14. **[Include when evaluation starts after the program]** What, if anything, could the program change at this point to make it more valuable for you?

15. Is there anything else you would like to ask or share? These could be questions or comments about the program and/or how it could be improved.

## Mid- or Post-Interview

This interview is designed to incorporate member-checking (participants reflecting on their own survey responses). Bracketed text indicates the survey question the interview is referencing and/or a placeholder for the participant's response. Ideally, charts would be created with all of the participant's previous survey responses for any mid or post interviews, providing a visual for participants to reflect on during the interview. The "general feedback" section reflects how evaluators solicited feedback about specific program elements during the TSRCP piloting effort; this should be modified to reflect the specifics of the program being evaluated.

### Interest

1. In the past you said that **[participant's response from previous responses to "Which aspects of the program are most interesting to you?"]** were the most interesting aspects--why might that have **[changed or stayed in the same]**?
    a. Probe: Is there anything surprising about this?
2. **[Post only]** On your survey you said you tend to feel **[participant's recent response to the question, "When I think about science, I tend to feel…"]** when you do science. Why do you feel that way?
3. Now we're going to do some member-checking about how your interests, confidence, and sense of community may have changed over time. On this slide **[graph with all previous responses to survey question #2]**, we have your survey responses about how interested you are in various topics. Looking at these data and drawing on your own perceptions, how would you describe your interests in science topics over the course of this program?
    a. Probe: Is anything surprising? What about the program contributed to those changes?

### Self-Efficacy

4. Now here's some of your survey data about your confidence in different research skills over time **[graph with all previous responses to question #5]**. How would you describe your confidence over the course of the program?
5. Probe: Is anything surprising? What about the program contributed to those changes?
6. And here's some of your survey data about your confidence in different science education and communication skills over time **[graph with all previous responses to question #6]**. How would you describe your confidence over the course of the program?

7. Probe: Is anything surprising? What about the program contributed to those changes?

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**Belonging and Recognition**

8. Alright and our last slide here is data about your sense of belonging in scientific communities [**graph with all previous responses to question #7]**. How would you describe your sense of belonging in these groups over time?

9. Probe: Is anything surprising? What about the program contributed to those changes?

10. Is there anything else you'd like to say about how you would describe your science identities [interest, skills & confidence, belonging] over the course of this program?

11. How, if at all, do you think this program contributed to those identities? What else might have contributed to those identities?

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**General Feedback**

12. How are things going with the program?

13. What, if anything, have you done in the program so far that has involved the core program elements **[provide list for participants to reference]**:

    1. Research practices
    2. Science communication practices
    3. Science education practices
    4. Mentorship from STEM professionals
    5. Becoming a member of a science community

14. Which of these do you think the program is doing the best? Why?

15. Which ones could we be doing better? Why?

16. How could the program do a better job with these core elements?

17. What, if anything, could the program change at this point to make it more valuable for **[you/future teens]**?

18. Is there anything else you would like to share? These could be questions or comments about the program and/or how it could be improved?

## **Meaning Mapping Activity** | Activity Guide

In this activity, youth to create and reflect on "maps" describing their own identities as well as scientist identities. Comparing these maps offers youth the opportunity to reflect on perceived overlaps or differences between the two.

**Estimated Time:**

- 30 - 45 minutes

**Materials Needed:**

- Blank paper (2 pieces per youth)
- Writing instruments

**Play**

Meaning Mapping can be used as a reflection activity with youth participants, or as an evaluation approach for observing youth STEM identities (as a snapshot, or to document change over time).

Begin the activity with a general conversation about identity, which could include:

- Discussing different dimensions of identity as a group
- Sharing about and discussing with youth how your institution defines or evaluates identity, as well as the rationale for that approach (if applicable)
- Watching a video and/or reading an article about identity and reflecting on the content (for suggestions, see **Resources**, below)
- Sharing a model meaning map and making observations of that map as a group
- The new dealer should hand out one additional Facilitation Strategy card to each player, and pick a Visitor Type card to start the next round.

**Describe**

On the first piece of paper, invite youth to take 5-6 minutes to describe who they are, in whatever way most resonates with them. Youth might consider things like their interests, what they are good at, and relationships or communities that matter to them.

Then, on the second piece of paper, invite youth to take 5-6 minutes to describe what defines a scientist. Youth might consider what scientists do, skills scientists have, and what science involves.

**Compare & Reflect**

Ask youth to compare their two maps and reflect on and share about any similarities or differences between the two. Make sure to establish a shared understanding of respect and trust for these conversations: participants should be able to share about their identities to the degree that they are most comfortable.

Some guiding conversation questions might include:

- Are there any words/imagery that appear on both maps for you?
- Where do you see the biggest differences between your own map and the scientist map?
- What words/imagery feel the most important to you across each map?
- Now that you are reflecting across both maps, are there any words/images that you feel are missing?

If time allows, invite youth to reflect on why certain identities may align better with (or be perceived as more aligned with) STEM identities.

If engaging with this activity more than once, over a period of time, ask: Have you noticed any changes in your maps between the last time you did this activity and now?

**Resources**

STEM Identity Interviews↗ | *Center for the Advancement of Informal Science Education (CAISE)*
This YouTube playlist includes several short videos in which Informal Science Education professionals reflect on their conceptions of STEM identity.

Extraordinary Grace↗ | SciEX
This video reflects on some of the ineffable dimensions of personal and science identity, and provokes viewers to consider “Can I be a scientist and still be me?”

## **Identity Research Reference List** | Resource List

**Resources**

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# 06 | Appendix

**Research Phases Infographic** ↗

This resource is a graphic organizer highlighting phases of the research process.

**Poster Development Guidelines - Example** ↗

This resource provides design and content guidance for research poster development.

**Science Process Skill Wheel** ↗

This resource provides a framework for defining science process skills and related actions.

**Science Process Skills Bingo Card** ↗

This resource is designed to be used in conjunction with the “Science Is An Activity” guide.

**Soaring Copter Engineering Template** ↗

This resource is designed to be used in conjunction with the “Interpretation Guide: Copter Engineering” activity.

**Universal Design Personas** ↗

This resource is designed to be used in conjunction with the “Designing with Accessibility in Mind” activity.

**Learner Type Cards** ↗

This resource is designed to be used in conjunction with the “Facilitation Strategies” activity.

**Facilitation Strategy Cards** ↗

This resource is designed to be used in conjunction with the “Facilitation Strategies” activity.

## Research Phases

### Literature review

- Choosing a topic
- Identifying scientific field(s)
- Searching and reading the literature
- Identifying “discovery avenues”
- Finding theoretical support
- Finding research support

### Study design

- Developing a research question
- Operationalizing your variables
- Thinking about analytical plans
- Choosing research paradigms and methodology
- Selecting and justifying your sample

### Data collection

- Recruitment/ procurement
- Running procedures with your sample
- Collecting and recording data
- Storing, entering, and organizing data

### Coding & analysis

- Data cleaning
- Data conversion (e.g., transcription)
- Data coding
- Analytical coding (e.g., dummy coding, categorical coding)
- Data visualization & analysis

### Communication findings

- Posters / synopsis
- Manuscript writing & publication
- Social media (e.g., ‘academic twitter’)
- News media
- Local institution partnerships (e.g., MoS)

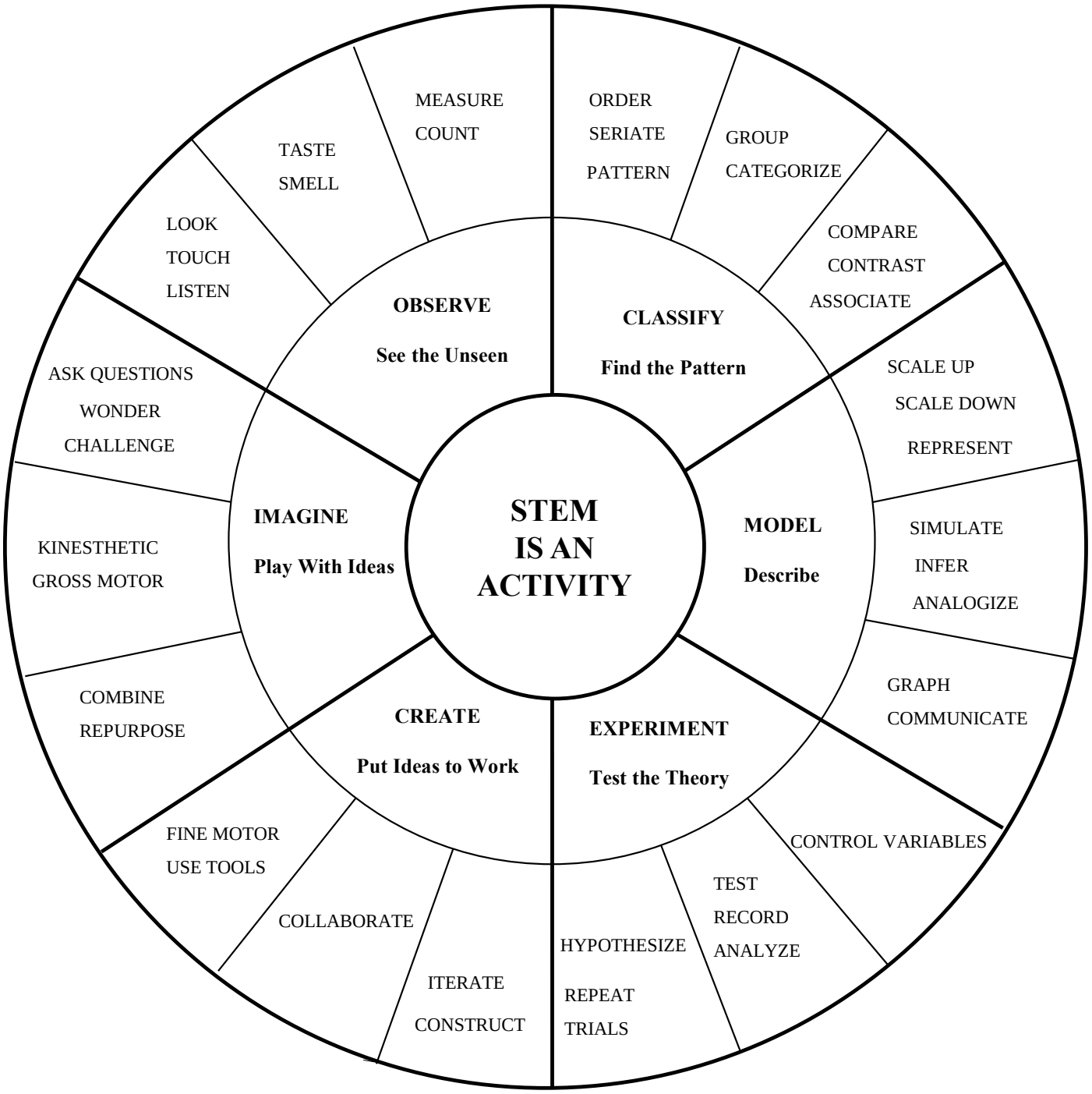
# Poster Development Guidelines - Example

| Formatting Guidelines | |
|---|---|
| **Layout** | • Include visual cues about how reader should travel through components (e.g., write the result as a header with an inset graph below; number figures; use callouts)<br>• Layer visual information by pairing text with icons<br>• Organize text in a sensical flow (e.g., most often, top-to-bottom, left-to-right)<br>• Use headings to help readers find content |
| **Graphics** | • Use high contrast, colorblind-friendly color combinations<br>• Choose a simple color scheme to create cohesion<br>• Avoid placing text over a patterned background or an image<br>• Cite image creators<br>• Make use of negative space to visually cluster related information<br>• Check image quality to avoid fuzzy/pixelated printing |
| **Text** | • Select an easy to read font (e.g. Calibri, Arial, Garamond)<br>• Left-align all text for readability<br>• Use font size to show information hierarchy (e.g. make the title largest, make references the smallest) |

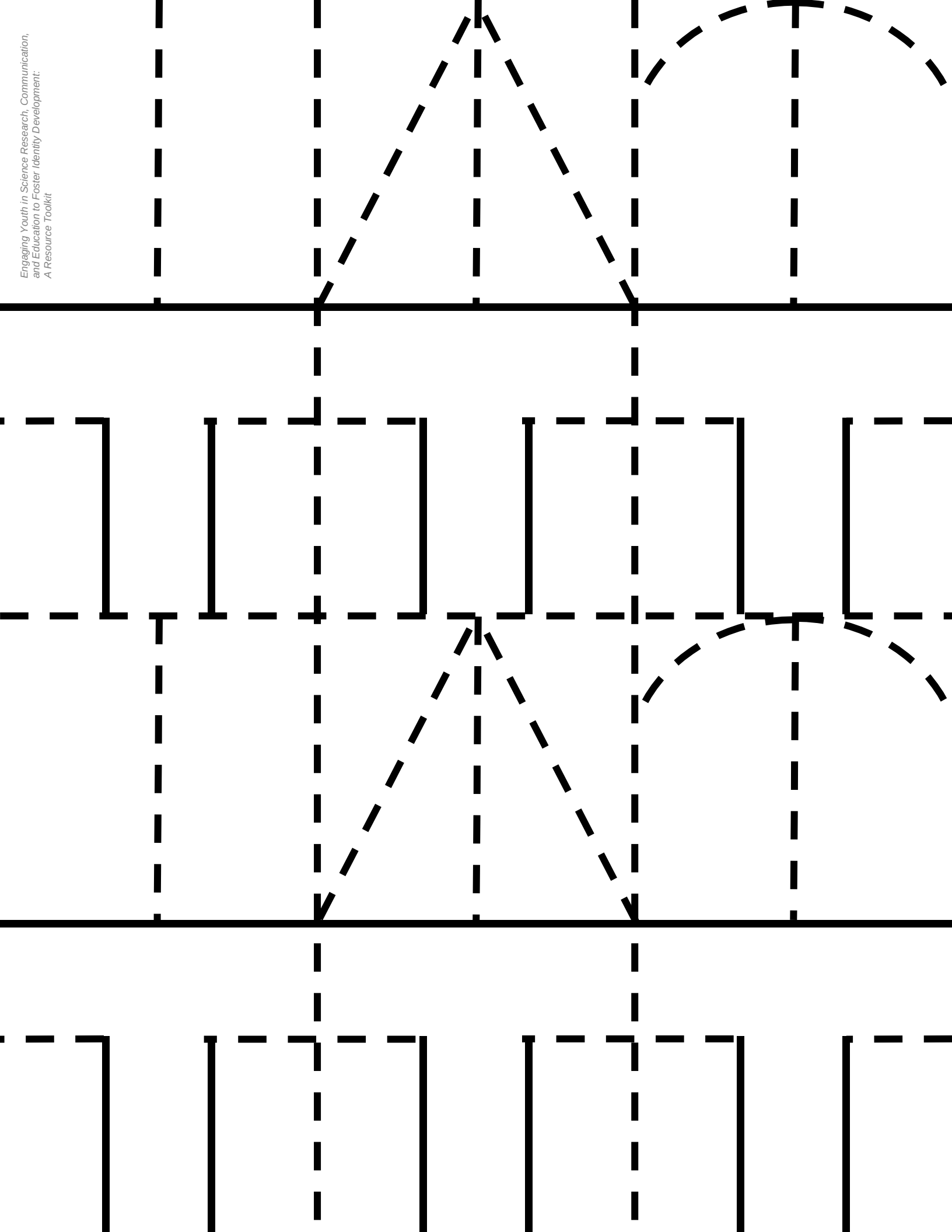
| Content Guidelines | |
|---|---|
| **Title and Authorship** | • Format text in “Sentence case” (not “Title Case”, not “ALL CAPS”)<br>• Keep the title brief and descriptive (1-2 lines)<br>• Title font size should be readable from ~6-10 feet away<br>• Include presenter name(s) and institution(s)<br>• Include funder and/or institutional logos (when applicable) |
| **Introduction** | • Visually emphasize the research question<br>• Share your “why”<br>• Define any topic-specific constructs or other jargon |
| **Methodology** | • Convey *general* experimental approach<br>• Use lightly annotated photographs, drawings, or flowcharts to visualize methods |
| **Results** | • Highlight or use arrows to draw attention to important info<br>• Consider bulleted lists for brevity |
| **Data Visualizations** (e.g. Tables, Graphs, Figures, Charts) | • Separate figures with plenty of white space<br>• Annotate or use captions to communicate to the reader how a particular figure or data point is interesting<br>• Strip away unnecessary clutter |

| Content Guidelines, continued | |
|---|---|
| **Conclusions** | • Make meaning of the results for the intended audience<br>• State why conclusions are interesting to the reader<br>• Consider including a discussion of potential future work |
| **References** | • Curate short list of relevant citations (2-4)<br>• Use APA formatting<br>• Alphabetize references<br>• Can use smaller font than poster body text |
| **Acknowledgements** | • Acknowledge support from others (e.g. mentors, assistants) and funders (generally required)<br>• Can use smaller font than poster body text |
| **General Considerations** | • Aim for less than 600 total words on a poster whenever possible to avoid visual clutter<br>• Identify the audience for your poster and write with them in mind<br>• Use numbered or bulleted lists (or images!) over paragraphs when possible to lighten reading burden |

# Science Process Skill Wheel



| | | | | |
|---|---|---|---|---|
| LOOK | ORDER | FINE MOTOR | GROSS MOTOR | SERIATE |
| GRAPH | PATTERN | COUNT | DESCRIBE | LISTEN |
| WONDER | MEASURE | CATEGORIZE | ASK QUESTIONS | TEST |
| CONSTRUCT | ANALOGIZE | REPURPOSE | HYPOTHESIZE | INFER |
| REPRESENT | REPEAT TRIALS | TOUCH | COMPARE/ CONTRAST | ITERATE |



# Universal Design Personas

## <u>Persona #1</u>: Identify accessible design features for visitors who may use or prefer…

- Multisensory and hands-on experiences
- Interactive exhibits that provide immediate sensory feedback

| What feature(s) did you find? |
| --- |
| |
| What exhibit did you find this feature in? |
| |
| How might this feature engage **all** visitors better? |
| |

## <u>Persona #2:</u> Identify accessible design features for visitors who may use or prefer…

- Experiences with audio interpretation
- Sighted guides
- Live shows with a presenter using descriptive language and tactile models

| What feature(s) did you find? |
| --- |
| |
| What exhibit did you find this feature in? |
| |
| How might this feature engage **all** visitors better? |
| |

## <u>Persona #3:</u> Identify accessible design features for visitors who may use or prefer…

- Foreign language guides
- Icons or pictures that provide orientation or instructions

| What feature(s) did you find? |
| --- |
| |
| What exhibit did you find this feature in? |
| |
| How might this feature engage **all** visitors better? |
| |

## <u>Persona #4:</u> Identify accessible design features for visitors who may use or prefer…

- Sensory-friendly experiences (low light and soft sound)
- Quiet spaces for taking a break

| What feature(s) did you find? |
| --- |
| |
| What exhibit did you find this feature in? |
| |
| How might this feature engage **all** visitors better? |
| |

## <u>Persona #5:</u> Identify accessible design features for visitors who may use or prefer…

- Open-captioning on videos
- American Sign Language (ASL) interpreters
- Visual or tactile feedback

| What feature(s) did you find? |
| --- |
| |
| What exhibit did you find this feature in? |
| |
| How might this feature engage **all** visitors better? |
| |

## <u>Persona #6:</u> Identify accessible design features for visitors who may use or prefer…

- Buttons or tactile objects within close reach
- Interactive experiences that use simple movements

| What feature(s) did you find? |
| --- |
| |
| What exhibit did you find this feature in? |
| |
| How might this feature engage **all** visitors better? |
| |

| | | | |
|---|---|---|---|
| Visitor Type | Visitor Type | Visitor Type | Visitor Type |
| Visitor Type | Visitor Type | Visitor Type | Visitor Type |

## The Hesitator

is interested in the learning experience, but might shy away from experiences that seem difficult, are uncomfortable with the possibility of appearing ignorant, and may need reassurance along the way.

## The Observer

is more comfortable sitting back and watching what is going on around them, and thinking through the experience on their own, before engaging in the experience directly.

## The Lone Wolf

is confident in their ability, values trying new things and enjoys the unexpected of the learning experience, but prefers to work independently.

## The Wolf Pack

is a group of visitors who are excited to talk and engage with one another, but are less attuned to the goals of the learning experience.

## The Template Bound

is engaged and motivated to try new things, but prefers to have directions, clear goals, and expectations set in advance.

## The Lifeguard

is eager to take part in the experience, but their anxiety of failure and fixed notions of how to engage with certain tools and processes can make it difficult for them to fully engage in the learning experience.

## The Novice

has never engaged with the tools or processes of this learning experience before, and may approach the experience with assumptions or not know what to expect or how to proceed.

## The Scout

is open, fully engaged and comfortable in the learning experience; they enjoy trying new things and sharing their explorations with others.

| | | | |
|---|---|---|---|
| Visitor Type | Visitor Type | Visitor Type | Visitor Type |
| | | | |

## The Window Shopper

loves to try new things and is drawn to activities that have a fast result, but may not have the patience to engage deeply or over time.

## The Apologizer

is excited to engage in new experiences, but may be worried about not getting the “right” answer or engaging in the “right” way.

## The Expert Seeker

is engaged and interested in the learning experience, but is more comfortable receiving a lecture than being asked questions.

## The Recharger

is excited to be in the learning environment, but prefers to let others lead while they take a step back and recharge (e.g. sit on a bench).

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Dare them | Ask them why | Ask them why not | Show off others' work |
| Give real world examples | Ask them to ask another | Ask them to teach another | Make them the model |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Ask them to teach you | Let them be the expert | Encourage planning | Tell them why you love it |
| Inquire about their process | Think about thinking | Grant permission to be silly | Simplify |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

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| Suggest a starting point | Expect greatness | Congratulate curiosity | Take away the finish line |
| Celebrate small victories | Work in parallel on something else | Think out loud | Feign ignorance |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

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|---|---|---|---|
| Tell them what to expect before they arrive | Abandon them once they are comfortable | Have them describe their actions to you | Be a quiet sounding board |
| Be the devil's advocate | Reassure them of their progress | Expose your own thinking | Introduce a new variable |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Step off the podium | Level the playing field | Scale up | Be patient |
| Create a real life comparison | Provide a reference | Be a model learner | Reassure them that failure is part of learning |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Reassure them of their abilities | Challenge them to expand their comfort zone | Make them feel like a scientist | Be a quiet observer |
| Model that it's fine not to know | Ask them about their visit | Ask for help | Ask for their opinion |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Introduce an activity, then step back | Give positive feedback | Wonder together | Take their perspective |
| Encourage playfulness | Empathize with them | Present a compelling task | Give them an objective |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Challenge their expectations | Surprise them | Make them the decision-maker | Invite competition |
| Indicate progress | Encourage trying again | Offer multiple levels of challenge | Acknowledge the challenge |

| | | | |
|---|---|---|---|
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |
| Facilitation Strategy | Facilitation Strategy | Facilitation Strategy | Facilitation Strategy |

| | | | |
|---|---|---|---|
| Invite reflection | Validate their feelings | Make them part of a team | Make them a team leader |
| Share a new tool | Offer a new perspective | Create a narrative | Show them their progress |