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Educator Fact Sheets

Educator tip sheets for facilitating high-quality out-of-school time learning

These educator fact sheets provide out-of-school time educators with research-based pedagogical (teaching) tips to help improve program quality and the experiences of youth participants.

Audience: Out-of-school time educators including 4-H professionals, 4-H volunteer educators, and afterschool or expanded-learning educators.

Purpose: Research-based pedagogical (teaching) tip sheets that span large content areas or program models.

Intended use: Supplemental handouts to Extension clientele (educators) after a workshop or training. Educators may refer to these fact sheets as they plan and implement a program with youth.

Out-of-school time learning

Educators must cultivate environments in which youth can develop a sense of agency, belonging, and competence.

Experiential learning: A cyclical process relying on a prepared educator who is knowledgeable in the content, able to ask reflective questions, and promotes group discussion and reflection.

Educators are among the most important contributors to program quality, and consequently to nurturing youth learning and development. Thus, educators need research-based information on effective teaching practices to increase their effectiveness.

Contents

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Science festivals: Very short science education engagements

Science festivals and expos offer very short engagements with hands-on science activities. Intentional design is needed to leverage these experiences for learning.

Science expos

Science expos are typically a large-scale, single-day event involving multiple groups providing hands-on science activities varying in disciplinary content.

The attendees, typically youth and parents or caregivers, interact with multiple exhibits, typically spending less than 10 minutes at any one exhibit.

Science expos are one format—commonly used as part of a broader "science festival" concept—to engage the public in science activities and provide a venue for scientists and science educators to interact with the public.

Nurturing wonder and curiosity

Science expos offer a unique environment for nurturing wonder and curiosity through surprise and novelty. Developing positive attitudes and interest for science is a component in strengthening scientific literacy.

Wonder: A feeling of surprise mingled with admiration caused by something unexpected.

Curiosity: Eagerness and a desire to learn more.

Wonder and curiosity are present when you see attendees laughing, asking questions, and continuing to engage with the activity.

Given the short length of interaction between attendees and exhibitors, usually less than 10 minutes per exhibit visited, science expos are unlikely to strengthen young people's scientific knowledge or reasoning abilities.

Increasing science awareness: Science expos improve public awareness of science in everyday life, nurturing an appreciation for science. Science expos help raise awareness of science careers youth might pursue in the future.

Core educational elements

Have an interactive and hands-on exhibit

Provide a hands-on activity with a link to science, technology, engineering, or mathematics.

Attendees prefer hands-on experiences where they can manipulate real-world objects. Engage youth in science processes such as observing, asking questions, interpreting data, handling materials, or constructing explanations. Or engage youth in engineering processes including designing, building, and testing.

Passive "information delivery" (including lectures, demonstrations, slide shows, and information-only displays) are typically not as well received. If you are providing a demonstration or passive display, include a related hands-on activity, too.

Pose an inquiry question

Develop and pose an inquiry question to explore.

An inquiry question (also known as a driving question) helps frame your activity in a broad science discipline. Effective inquiry questions are open-ended with no straightforward answer, connected to real science, feasible to explore within the timeframe (less than 10 minutes), and relevant and meaningful to youth.

Avoid dense scientific information

Dense scientific information may limit people's ability or willingness to interact with your activity.

Answer a question with a question

Invite young people to construct their own explanations, rather than giving them the answers.

Pause before giving answers. Encouraging young people to construct their own explanations helps promote deeper learning.

View example questions, sep.ucsf.edu/wp-content/uploads/2024/03/Questions-are-the-Answer.pdf

Provide prepared prompts to parents

Provide prepared prompts and questions to guide parents and caregivers' conversations with youth.

Conversations with parents and caregivers play an important role in their children's learning. Parents and caregivers need to encourage youth to ask questions and construct their own explanations rather than telling them the answers. This is very difficult for most adults. Provide parents and caregivers a poster or handout with information or prompts to guide their conversations with their children.

Promote interactions with a professional scientist or engineer

Have a clearly identified professional scientist or engineer at your exhibit.

Science festival attendees were more satisfied, had more fun, and reported better learning when they interacted with a professional scientist or engineer.

Stay positive and have high energy!

Smiling exhibitors with high energy and enthusiasm will improve interactions and attendees' experiences.

Author: Steven Worker

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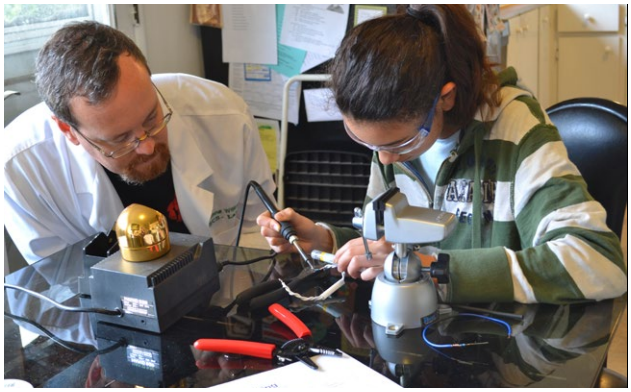

Making and tinkering

Making and tinkering are educational approaches for STEM learning that offer opportunities to design, build, and test shareable artifacts through open-ended playful experimentation.

Design and playful experimentation

Making and tinkering involve the fabrication or modification of objects by repurposing, reusing, and upcycling. **Making** involves digital tools to design, create, and share technology-based projects emphasizing a spirit of innovation and creativity. **Tinkering** involves hands-on open-ended activities where youth play, try out ideas, make adjustments, and experiment with possibilities. Both are educational approaches to **engineering design** that emphasize planning, designing, and making shareable artifacts through playful experimentation—an iterative style of continually reassessing goals, exploring new paths and designs, reframing failures as drafts, and imagining new possibilities.

STEM learning

Making and tinkering allow youth to flex their creativity, grow their cultural identity, and nurture pride in something they built. These learning outcomes go beyond traditional learning indicators. Other learning indicators include:

- **STEM understanding:** Growing one's ability to innovate and solve problems using scientific knowledge.
- **Psychological ownership:** Improving engagement, authenticity, agency, and motivation by creating, shaping, and producing something.
- **Materials literacy:** Strengthening understanding of material affordances, constraints, adaptabilities, reusability, and repurposeability.

> While tinkering activities have particular parameters and goals … they are intentionally designed to support multiple pathways and to imply a range of solutions — Vossoughi et al. 2013.

Core educational elements

Spark, deepen, and sustain learning

Educators must be intentional to spark, deepen, and sustain participation:

- **Spark** interest through demonstrations, modeling, or questions, and orient youth to the activity at hand. Establish safety so participants can take risks.
- **Deepen** participation by fostering reflection or challenging learners to add complexity to their work.
- **Sustain** involvement by offering new tools or suggestions, welcoming ideas, and re-engaging youth when interest wanes.

Provide scaffolding; avoid the swoop

Provide just enough support (instructions, tools, and questions) to allow youth to accomplish the task, but do not swoop in and do it for them.

Scaffolding is the support an educator provides to help youth accomplish tasks, overcome obstacles, and learn from failure while persevering. Scaffolds may be instructions, questions, prompts, guidance, questions, tools, or hands-on support. Scaffolds are educationally appropriate, but the swoop is not. When educators swoop in and fix artifacts themselves, they prevent youth from developing STEM understanding, ownership, materials literacy, or the ability to learn from failure.

Schedule reflection time

Dedicate time for youth to share, process, and generalize their experience.

Connecting individual and group reflection after a hands-on activities is vital for deeper learning. Reflection happens through individual writing or journaling, group discussion, educator questions and prompts, and youths' presentations of their work.

Cocreate together (youth plus adults)

Educators must become co-designers with youth and not the primary teacher or knowledge holders.

Keep groups small

Collaborative work is valuable, but each team should be limited to two to three individuals. In addition, each team member should have a designated role.

Collaborative work provides opportunities for joint problem solving and, in the process, teaches participants to give and receive peer feedback. However, too many youth (more than three in a group) will inhibit some participants' contributions. Also, many youth need teamwork support, so designating formal roles (designer and builder; or manager, builder, and reporter) can help ensure that youth are all actively contributing.

> Learning through tinkering is not serendipitous: it comes about through a process of design decisions and principles that create specific types of opportunities for learning — Petrich et al. 2013.

Author: Steven Worker

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Youth Participatory Action Research

In youth participatory action research (YPAR), youth strengthen their collective scientific literacy and critical consciousness by planning and conducting a research project and use the results to improve their communities. Intentional youth-adult partnerships and educator skills are needed to realize YPAR potential.

Youth-led research and change

Youth participatory action research integrates science education and civic engagement to promote youth and community development.

The core YPAR approach is to empower youth—with adult help—to choose a research topic; design and implement the research (including selecting methods, collecting and analyzing data, and interpreting and sharing results); and then plan a service project based on the research findings to improve their lives or community.

YPAR can be used with groups of young people of any age; the research and action projects will vary depending on their ages and capabilities. YPAR is an extension of participatory action research; also known as community-based participatory research.

- Form the team and build team identity
- Define the issue and select a topic
- Investigate (collect and analyze data, interpret results)
- Take action for community change

Basic steps

Promoting science learning and critical consciousness

YPAR strengthens young people's scientific literacy and critical consciousness.

Scientific literacy: Scientific literacy includes four anchor points: (1) science content (varying disciplinary content), (2) scientific reasoning skills, (3) interest and attitudes, and (4) contributions through applied participation (Smith et al. 2015).

Critical consciousness: Improving young people's awareness of social inequality, perceived ability to enact change, and actively engaging young people in changing conditions.

> **What did you learn?**
> I think more than anything, to conduct scientific or more detailed research, I think that was the biggest—what I learned most. Because I think I would not have analyzed what problems society has as a whole and how to solve them – Damiān, age 16, 2019 interview

Core educational elements

Respectful youth-adult partnership

Adult educators must elevate and empower youth voices and share decision making.

A key factor in the success of YPAR is the presence of supportive, caring adults, who are willing to share power and establish productive youth-adult partnerships. Core elements include:

- youth voices and authentic decision making; youth take on leadership roles
- developmental relationships and respect between youth and adults; adults are willing to work collaboratively
- co-learning and collective reflection

Community connectedness

Build and strengthen young people's connections with community leaders, resources, and allies.

Leverage the wisdom in our communities by intentionally helping youth build relationships to each other, to place, and to community.

> Promoting self-awareness encourages the capacity for youth to think critically about issues in their own communities. The ability of young people to provide an analysis of complex community problems is a powerful tool they can apply throughout their lives — Ginwright and Cammarota 2002.

Topic selection: Autonomy and agency

Youth will be more motivated working on a meaningful topic that they selected themselves.

Even before recruiting youth into a YPAR program, any guidance and constraints on acceptable topics must be established and shared. Constraints might be due to funding sources or organizational priorities. We recommend having no constraints and allowing youth to select any topic. Young people will be more motivated to participate when the topic reflects their interests and is personally meaningful.

Rely on a high-quality curriculum

A high-quality curriculum may help guide the process, recognizing that YPAR requires educator flexibility and group adaptability:

- UC Davis Community Futures, Community Lore: ypar.cfcl.ucdavis.edu/
- UC Berkeley YPARHub: yparhub.berkeley.edu/
- Stanford Youth Engaged in Leadership and Learning (YELL): gardnercenter.stanford.edu/publications/college-career-and-civic-readiness/youth-engaged-leadership-and-learning-yell-handbook

Author: Steven Worker

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Environmental education

Finding solutions to environmental issues will depend on helping young people become civically engaged and scientifically literate. Educators must engage youth in authentic, place-based environmental issues, so they become stewards and advocates.

Creating a sustainable future

Environmental education is an organized effort to help youth learn more about their natural and human-made locations, think critically, and develop skills, motivation, and commitment to take action to conserve and create a more sustainable future.

Think globally, act locally

Environmental education builds from core principles:

- **Experiential:** Learning is through direct experience with the environment.
- **Human interdependence:** As part of nature, humans depend on and influence the environment. We need to understand our interdependence with the Earth.
- **Systems thinking (think globally):** To make sense of a large and complex world, youth need to explore relationships and interactions (perspectives on ecosystems).
- **Start locally:** Youth are natural scientists and begin to explore nature around them at home and in their communities.

Environmental education crosses subject matter areas—ecology, geology, and atmospheric science—and happens in school and during out-of-school activities (in programs, science museums, and clubs).

Growing scientists and stewards

Environmental education helps strengthen young people's scientific literacy and motivation for making positive environmental change.

- **Scientific literacy:** Youth learn science content (varying disciplinary content depending on the specific program) and scientific reasoning skills, while also improving their interest and attitudes toward science, and making contributions through applied participation.
- **Environmental stewardship:** Youth engage in environmentally friendly behavior (like reducing water use, recycling more, and participating in clean-ups) and improve their feelings of civic responsibility and abilities to take action.

> Environmental education is learner-centered, equitable, inclusive, and culturally relevant and responsive, providing all participants with opportunities for minds-on, developmentally appropriate experiences and investigations — NAAEE 2022.

Core educational elements

Authentic and place-based learning

Engage youth in exploring a real-world issue, starting with something they are familiar with.

Authentic learning centers relevant, real-world issues that are of interest to learners. Start with immediate surroundings and the natural world familiar to youth before moving into larger systems or broader issues.

Experiential education

Focus on helping youth share, process, and generalize from a direct experience, and then apply new knowledge and skills in a similar situation.

Experiential education is a powerful teaching method, well suited to environmental education. The educator becomes a facilitator of learning, and not the expert, with responsibilities for inspiring reflection through prompts and questions.

Project-based learning

Offer long-term learning activities where youth can organize their own work on a project.

Project-based learning involves youth in a long-term project, typically based on a driving question where they work in groups to conduct background research, design plans, debate ideas, test ideas/solutions, and communicate results or physical artifact. Project-based learning is well-suited to environmental education where youth can be involved in proposing and advocating for conservation and sustainability projects.

> Environmental education programs, which occur across a range of settings and in various configurations, have positive outcomes in terms of environmental knowledge, attitudes, dispositions, and skills — Ardoin 2018.

Author: Steven Worker

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Computational thinking

Cultivating young people's computational thinking will help them thrive in today's digital society. Educators must make intentional choices of technologies to enhance learning outcomes.

Using computing to explore, analyze, and understand problems

Computational thinking is the thought processes used to formulate problems in a format that can be solved by a combination of humans and computers (similar to logical thinking and problem solving).

Computational thinking is used heavily in computer science, in other disciplines (like science, engineering, and social science), and in daily life.

Thinking like a computer scientist

When confronted with a problem, computational thinking involves the following elements:

- Decomposition: breaking problems into smaller parts. *Like making a to-do list to clean your room with individual tasks—breaking it down into manageable tasks.*
- Abstraction: finding patterns and generalizing solutions for similar problems; and dealing with complexity. *Like an escape room where people need to solve a problem by separating out the relevant details while ignoring unimportant information.*
- Algorithms (design, parallelism, efficiency, and automation): develop re-usable procedures. *Like creating a recipe or rules to a board game—a set of steps.*
- Debugging (to ensure each smaller part is solved efficiently). *Like testing, figuring out what works and does not work, making improvements, and testing again.*

> Computational thinking is not just or all about computer science. The educational benefits of being able to think computationally—starting with the use of abstractions—enhance and reinforce intellectual skills, and thus can be transferred to any domain — Wing 2011.

Developing computational thinkers

Helping youth develop computational thinking allows them to become more efficient with technologies, enhances their creativity and innovation, shifts their identity to seeing themselves as someone who uses computers and could become a computer scientist, and improves aspirations to pursue a STEM career.

The advent of powerful computer technologies—technologies that have incredible capacity for logical, boring, and repetitive tasks—calls for young people to acquire competency and effectively harness this computing power to develop innovative solutions.

Core educational elements

Access to computer technologies

While computational thinking may be developed in other subject areas, it is easiest to develop with access to computer technologies.

Educators have used the following to help youth strengthen their computational thinking: programming or coding, robotics, or microcontrollers.

Technology: Low floor, high ceiling

The tool should be easy for beginners and powerful enough for experts.

A core tenant of learning any computer technology is that it's easy for beginners to get started but offers extensive enough capabilities for advanced programmers. Other considerations include transferability to other technologies, support equity, and sustainability. Example technologies include: Scratch, Alice, Kodu, Agentsheets, Arduino, and BBC micro:bit.

Keep groups small; consider gender participation

Collaborative work is valuable and limits group size; pay attention to gender roles.

Collaborative work provides opportunities for joint problem solving, while also offering the option to give and receive peer feedback. However, too many participants will limit the ability of some individuals to fully contribute. Also, pay attention to the ways gendered groups work together and switch groups around if needed.

Schedule reflection time

Dedicate time for youth to share, process, and generalize their experiences with each other.

Linking hands-on activities with individual and group reflection is key to deeper understanding. Reflection happens through individual writing/journaling, group discussion, and educator prompts and questions.

The power of unplugged learning

For beginners, facilitating unplugged hands-on activities (no computer needed) helps introduce computational thinking concepts.

Solving problems using data and designing solutions is a fundamental human skill rooted in non-digital (unplugged) approaches. Unplugged experiential activities will help youth develop a deeper understanding of computational ideas.

> We advocate for combining unplugged and plugged activities to provide students with an opportunity to fully understand and take advantage of the power of computing and prepare them to thrive in today's society — Caeli and Yadav 2020.

Author: Steven Worker

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Public speaking

Informal and formal presentations provide opportunities for youth to develop public-speaking skills while gaining confidence speaking in front of others.

Developing public-speaking skills and confidence

Public speaking is an essential skill needed to be successful in both personal and professional life. However, speaking in front of others is one of the most common fears. Skills and confidence are both needed for successful public speaking. Skills include developing the content and structure of presentations, as well as presentation delivery and mechanics.

Public-speaking confidence (or self-efficacy) is the belief in one's ability to successfully present a speech with effective content, structure, and delivery. Therefore, providing opportunities for youth to practice public speaking is essential to building their skills and confidence speaking in front of others.

Youth learning outcomes

In public-speaking education, young people need to learn three basic speech components.

Speech components

A competent speaker must be able to develop well-organized, high-quality content—and must also have good delivery skills.

Content

The purpose, information, and ideas which are presented make up the content of a speech or presentation. This is the message which the youth is trying to get across to the audience. The knowledge, depth, and breadth of a presenter's content may vary depending on age and ability. The sources or references of the content are an equally important part of the content.

Structure

An effective speech or presentation is well organized. It includes an introduction, body, conclusion, and transitions between sections, as well as opening devices. Several approaches can be considered when organizing the main points; the structure of a speech can be chronological, spatial, causal, problem-solution oriented, or topical.

Delivery/mechanics

How a speech or presentation is delivered may impact how it is received. Delivery includes how the voice and body are used by the speaker during a speech. Considerations when focusing on the voice may include volume, pitch, rate, pause lengths, and repetitions, while physical factors include personal appearance, movement, gestures, and eye contact.

Core educational elements

Youth need to give presentations; focus on positive presentation experiences.

Practicing public speaking is the most impactful in influencing public-speaking confidence.

Practicing public speaking alone will not result in improved public-speaking confidence. Youth need to have *positive* experiences speaking in front of others to build their public-speaking confidence. Similarly, too many negative public-speaking experiences may be harmful to youths' confidence in their public-speaking abilities.

Increase the number of speaking opportunities and remove barriers to participation

Access to public-speaking opportunities is essential to ensuring youth participate in experiences which may help expand their confidence.

Increasing the number of public speaking opportunities available gives youth more chances to practice their public-speaking skills and build their confidence. Likewise, ensuring that public-speaking opportunities are accessible to youth is important. Requirements for specific scores or ranks to participate in an event may deter youth from participation, limiting the number of opportunities for practice.

Incorporate play and experimentation into public-speaking practice and opportunities.

Including play and experimentation in a low-stakes environment encourages youth to learn new public-speaking techniques and skills.

Play and experimentation have been techniques for learning public speaking since ancient Greek orators addressed the assembly. However, public speaking for youth is often tied to competitions or grades—which limits the ability to incorporate play and experimentation into speeches—as the speaker pushes for the highest grade or score. Play and experimentation refer to using impromptu activities, allowing youth to try new approaches and take part in informal speaking engagements.

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