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PRIMING THE PIPELINE
Lessons from Promising 4-H Science Programs

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Executive Summary

Since 2006, the 4-H Youth Development Program's National Science Initiative has promoted the development and growth of 4-H clubs, camps, and school-based programs that give youth opportunities to engage with science. The 4-H Science Initiative, supported by the Noyce Foundation, was introduced as a way to teach science, technology, engineering, and applied math content to the more than 6 million youth who participate in 4-H annually. It has had the goals of engaging more young people in science and related fields and increasing the number of youth pursuing postsecondary education and careers in science.

Now, the time is right to examine lessons learned in implementing these programs: how they have tackled problems of recruitment, staffing, programming, partnerships, and sustainability. This report describes the challenges met and practical strategies employed in eight promising 4-H science programs. Selected through a structured process of nominations and vetting, the programs studied for this report reflect a variety of program delivery modes, content areas, geographic regions, and youth served. They include the following:

- Adventure in Science (AIS) (Montgomery County, Maryland)
- Bucks County Vet Science Clinics (Bucks County, Pennsylvania)
- GEAR-Tech-21, A'ROR'N Bots (Aurora, Nebraska)
- 4-H Great Lakes & Natural Resources Camp (Michigan)
- Langston Community 4-H SET Team (Logan County, Oklahoma)
- Montana Sustainable Communities Project, Pretty Eagle (St. Xavier, Montana)
- Rutgers 4-H Summer Science Program (New Jersey)
- Texas 4-H Technology Team (Texas)

Promising practices in these programs are not necessarily sure-fire solutions for other settings, but they may spark useful reflection and action by 4-H Science staff and volunteers. These program practices are discussed here under eight headings: youth outreach and recruitment; staff and science volunteers; professional development; science curricula and pedagogy; youth development and attitudes toward science; partner organizations and resource support; program evaluation; and program sustainability and scale-up. This summary provides a few examples of program practices, and many additional examples appear in the full report.

Youth Outreach and Recruitment

Promote recruitment through "word of mouth." Several programs encourage youth and parents to tell others about the program; some publicize their programs at 4-H events and through existing 4-H networks.

Invite participants to contribute to the recruiting process. The Rutgers Summer Science Program benefits from the formal and informal recruiting led by previous participants. The Texas 4-H Technology Team, which is composed of youth with advanced technological skills, relies on members not only to help identify potential members, but also to consider applications and decide who will be accepted onto the team.

Recruit youth through partner organizations and parents. AIS has established several long-term partnerships with local organizations that host programming and has advertised activities at its host sites through organizational newsletters and bulletin board postings. As a result, the program enrolls children whose parents are employees of the host organizations.

Design the application and acceptance process to build the desired participant group profile. The rigorous application process for the Texas 4-H Technology Team assesses applicant skills, interests, and commitment. The process itself is an opportunity for applicants and selection committee members to develop useful life and career skills.

Design strategies to recruit underrepresented youth. For example, ongoing partnerships with several schools help the Rutgers Summer Science Program to recruit heavily from underserved urban communities surrounding the university.

Staff and Science Volunteers

Include science experts as site leaders and advisors. The GEAR-Tech-21 A'ROR'N Bots club leader has a doctorate in agricultural engineering; AIS's site leadership and board of directors are composed mostly of scientists from industry and federal agencies; and the Rutgers Summer Science Program is co-led by a marine science educator.

Recruit scientists to deliver the science content they know and love. Six of the eight programs draw heavily on science experts. These volunteers' scientific backgrounds and professional perspectives provide an authentic window into the practice of science.

Maximize the expertise of youth development staff and volunteers and clarify their roles alongside scientists. Most science experts do not have deep expertise in youth development and can benefit from the support of those who do. In the 4-H Great Lakes & Natural Resources Camp, program coordinators help science instructors develop lesson plans, and youth development volunteers provide support as needed in instructional sessions. The Langston SET Team director, an extension agent with a science background, helps volunteers make their activities more hands-on, accessible, and engaging to youth.

Cast a wide net when recruiting science experts, then tap the specific expertise needed. "Science experts" need not include only university and lab scientists. These programs have recruited from a wide range of businesses and other organizations and have found individuals whose knowledge ranges across many fields of science, engineering, and technology.

Recruit scientists through networks and perpetually tend to the relationships in those networks. Volunteer recruitment is made easier when leaders have already made a concerted and successful effort to establish and maintain relationships in their informal networks. Recruiting efforts can also benefit from tapping into existing organizational networks.

Look for scientist volunteers who work well with youth, and consider partnering with K-12 teachers and schools. The Montana Sustainable Communities Project draws on the

capacities and roles of partners from Pretty Eagle Catholic Academy and Montana State University. These teachers have been integral in developing the structure of the program.

Professional Development

Make it easy to access and use professional development. These programs have developed training materials and delivery that minimize the burden on staff and volunteers and maximize the uptake of essential content. Some developed user-friendly materials that provide practical guidance and can be accessed by volunteers on their own time.

Provide guidance to science experts on lesson planning, delivery, and youth development. Program staff and volunteers with science-related expertise may need professional development and guidance in order to support youth engagement and learning. The 4-H Great Lakes & Natural Resources Camp training manual describes principles for positive youth development, age-appropriate youth development experiences, and means of fostering character development in youth.

Provide guidance to educators and youth development experts on science curricula and technology. While teachers and youth development staff and volunteers have skills in working with youth, they may benefit from training on the particulars of program content, and from guidance on how to facilitate science activities. GEAR-Tech-21's curricular modules provide detailed guidance in a user-friendly layout for each activity, as well as companion educator guides for each module. The program also offers online training modules, webinars, and a two-day training program.

Science Curricula and Pedagogy

Take advantage of the opportunity to maximize youth-centered delivery. For example, AIS includes an independent project that spans several months in which youth take control of their own learning, behave as scientists, and receive mentorship from practicing scientists.

Develop student skills and knowledge through experiential learning and real-world applications of science. Youth in the Vet Science Clinics spend their sessions conducting dissections in animal science laboratories and meeting with practicing animal scientists.

Incorporate inquiry in activities. Robotics and other engineering design challenges, such as those in the GEAR-Tech-21 curriculum, offer an opportunity for youth to apply their own hypotheses and tests as part of the design process. Youth must predict, evaluate, and substantiate design trials, and often they are asked to do so in a team.

Manage a realistic yet productive balance between adaptation and fidelity of an adopted curriculum. By design, some curricula – such as GEAR-Tech-21 – promote fidelity to their essential features while leaving room for local customization of other features.

Enable volunteer science experts to develop their own curriculum, driven by their expertise and passions. Such a curriculum will be rooted in the volunteer's own deep professional knowledge and love for the topic.

Develop content targeted toward participant skills and interests. The Vet Science Clinics recruit youth with strong, pre-existing interests in science, and the program tailors its more advanced program content based on youth skills and prior experiences.

Youth Development and Attitudes toward Science

Provide opportunities for the development of positive relationships in a science context. Science activities observed in the programs had youth engaged collaboratively in hands-on activities, predicting and evaluating through group discussion, and spending some unstructured social time in a science-oriented setting. There were also opportunities for youth to talk informally with adults about science and non-science topics.

Structure science activities to promote the development of life skills. The Langston 4-H SET Team offers activities in which staff and volunteers help youth gain confidence in public speaking.

Involve youth in their communities through science projects. Youth who have participated in the Rutgers Summer Science Program have organized afterschool activities and demonstrations for younger youth in their communities based on the content learned during the summer camp. In the Montana Sustainable Communities Project, youth learn about film technology as they create a short film on a science-related topic of their choosing, often related to an issue in their community and sometimes including interviews with community members.

Build opportunities for youth to serve in leadership roles. Former campers often return to the 4-H Great Lakes & Natural Resources Camp as camp counselors who serve as mentors for current participants. When asked what it is about the Langston 4-H SET Club that keeps them coming back, participants noted that their role in teaching younger youth was a draw.

Enable youth to make meaningful choices about what they learn and how they learn it. In the Texas 4-H Technology Team, content is partially driven by youth interest and input. At the fall meeting, the team works together to establish goals for the full year.

Develop program activities that expose youth to diverse science fields and careers. The Langston 4-H SET Team designs programming in a variety of science topics. Youth in the Vet Science Clinics work closely alongside volunteers who have careers in animal-related industries.

Partner Organizations and Resource Support

Draw human resources and science expertise from organizational partnerships. Partnerships can provide program volunteers who have expertise in science, youth development,

research, curriculum development, and marketing. For the programs studied, partners include university departments, research laboratories, science-focused grant projects, government agencies, and corporations.

Look for low-cost ways for organizations to partner and make substantive contributions. In addition to potential volunteers, partners offer other non-monetary resources such as their scientific and educational cultures, knowledge resources, reputations, and facilities.

Consider deeper partnerships with schools. The Montana Sustainable Communities Project at Pretty Eagle established and maintains a strong relationship with its host school. Not only are teachers active in planning, recruiting, and content delivery, but ongoing professional development and support from the program's staff has encouraged teachers to integrate the program's modules into the school's curriculum.

Approach partnership development mindfully and persistently. Program staff consider their partners essential for program success. They have worked hard to establish strong partnerships and tend to them regularly through formal and informal communication.

Program Evaluation

Design evaluations to provide data that are useful for securing additional funds, partners, visibility, and for guiding continuous program improvement. When asked what evaluation data have proven most useful, a 4-H Great Lakes & Natural Resources Camp program director pointed to data on several topics: aquatic science literacy; appreciation and stewardship of natural resources; interest in science careers; youth development skills; and participant intention to stay in Michigan. Because these topics align well with the program's goals, the data have enabled directors to analyze the program's progress toward those goals.

Program Sustainability and Scale-Up

Improve sustainability and replication by codifying and institutionalizing key program features, such as procedures, content, training, and partner relationships. Both large and small programs can benefit from efforts to institutionalize key program features. For example, the Texas 4-H Technology Team annually updates a handbook that guides the team's activities, structure, and content for the program year, providing a common reference point for new and long-term members, youth and adult.

Plan for sustainability and replication through program and evaluation design. As the Montana Sustainable Communities Project's program design evolved, program staff used strategies to support programming at Pretty Eagle at the end of its CYFAR grant. GEAR-Tech-21 developed a suite of resources to facilitate new club startup.

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Overview

Since 2006, the 4-H Youth Development Program's National Science Initiative has promoted the development and growth of 4-H clubs, camps, and school-based programs that give youth opportunities to engage with science. Now, the time is right to examine lessons learned in implementing these programs: how they have tackled problems of recruitment, staffing, programming, partnerships, and sustainability. This report describes the challenges met and practical strategies employed in eight promising 4-H science programs (text boxes below describe these programs and their selection). While the practices we describe here are not proposed as sure-fire solutions for other settings, we believe that the lessons shared by the leaders, staff, and volunteers at these programs can spark useful reflection and action elsewhere.

We have structured this report around eight domains of practice in which 4-H staff and volunteers often encounter challenges as they plan, implement, and sustain their 4-H programs. For each domain, we describe several practices that have worked well at one or more of eight promising programs visited for this study. In some cases, the practices are supported by research evidence. In others, the practices are innovative and promising for specific program types or contexts. The report concludes with a summary and overview for 4-H staff and volunteers. Appendices profile the eight programs and their notable practices, and describe our methods of program selection and data collection.[1]

Domains of Program Practice

This report describes promising 4-H science program practices in the following domains:

- Youth Outreach and Recruitment
- Staff and Science Volunteers
- Professional Development
- Science Curricula and Pedagogy
- Youth Development and Attitudes Toward Science
- Partner Organizations and Resource Support
- Program Evaluation
- Program Sustainability and Scale-Up

Background and Rationale

The 4-H Youth Development Program , with support from the Noyce Foundation, began the 4-H Science Initiative with the goals of engaging more young people in science and related fields and increasing the number of youth pursuing postsecondary education and careers in science. The 4-H Science Initiative was introduced as a way to teach science, technology, engineering, and applied math content to the more than 6 million youth who participate in 4-H annually. Since the start of the Science Initiative in 2006, the county-level focus on science has generally increased, according to a 2012 survey of county 4-H agents (Mielke & Sanzone, 2012).

[1] See Appendix A for Methods and Appendix B for Program Profiles.

4-H's actions over the past six years to strengthen youth engagement and skills in science have been in line with national priorities to strengthen science education in informal, out-of-school environments. The President's Council of Advisors on Science and Technology (PCAST) in its 2010 report on K-12 science, technology, engineering, and math education recommended that the federal government should "create opportunities for inspiration through individual and group experiences outside the classroom" in order for youth to "develop personal connections with the ideas and excitement of STEM fields" (PCAST, 2010). 4-H science programs are intended to give youth opportunities to forge personal connections with science as well as build youth science knowledge and skills.

STEM Education Pipeline Context

- 27% of high school graduates are ready for college science*
- 43% of high school graduates are ready for college math*
- 16% of U.S. bachelor's degrees are in STEM fields, lower than South Korea (38%) and Germany (28%)‡

- 4-H serves over 6 million youth
- 4-H Science Initiative began in 2006
- 4-H county agents were surveyed in 2012:◆
  - 73% reported that their county places more emphasis on science programming than it did before 2006
  - 89% reported that their county placed a high or moderate priority on science programming

* Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2011.
‡ National Science Board Science and Engineering Indicators, 2010, appendix table 2-35.
◆ Mielke & Sanzone, 2012.

4-H expects its science programs to provide skill-driven, experiential learning opportunities in a positive youth-development context. These expectations are in line with research on youth development and informal science programming: for example, Eccles and Gootman found that successful out-of-school programs not only promote the learning of content and skills, but also enable youth to develop positive relationships among themselves and with program staff that are different from the relationships that they build during the school day (Eccles & Gootman, 2002).

The 4-H Science Initiative supports programs that provide opportunities for youth to develop an interest in science, including science careers and pathways. In reviewing studies of science learning in informal environments, the National Research Council found indications that "participation in out-of-school programs focused on science and mathematics can support more positive attitudes towards science" and that participation in such programs is "associated with interest in science and science careers among children and adolescents" (National Research Council, 2009).

Previous evaluations of the 4-H Science Initiative examined the implementation of science programming at state and local levels in order to identify areas of success and challenge. In a recent survey, county 4-H agents reported offering a broad range of science content to youth, placing a high value on experiential learning, and finding partners to support science programming (Mielke & Sanzone, 2012). The results of this survey of county agents also pointed to common stumbling blocks. First, while experiential learning was reportedly widespread, inquiry-based learning was less so. Second, programs reported challenges in finding science content experts and finding qualified youth development staff and volunteers. Finally, although most county agents reported that staff and volunteers need professional development in

science content and in how to teach science concepts to youth, fewer counties were delivering such training.

In order to identify ways in which successful 4-H science programs overcame these and other challenges, and to identify other strategies for implementing high-quality 4-H science programs, we visited eight promising 4-H science programs to learn from their experiences.

Promising 4-H Science Programs

Summary of program selection and methods. In order to identify promising 4-H science programs that represented a cross-section of the 4-H community, the study team partnered with the 4-H Youth Development Program to carry out a structured nomination and vetting process. The following programs were nominated by program directors and club leaders nationwide, assessed by a committee of 4-H science liaisons and evaluators, and selected for inclusion on the basis of additional data gathered by a team of external researchers (Policy Studies Associates) and 4-H evaluators. These programs were selected not only because of their strong implementation practices, but also because they represented a variety of program delivery modes, content areas, geographic regions, and youth served. *The appendices of this report include a fuller description of these program selection methods, as well as profiles of the eight selected programs.*

Adventure in Science (AIS) (Montgomery County, Maryland) – AIS, a program started over 30 years ago by a scientist in his basement, is facilitated by a 4-H county extension agent and managed by volunteer scientists at four locations: National Institutes of Health, National Institute of Standards and Technology, Lockheed-Martin, and Urbana Middle School. It is a year-long program of Saturday sessions presented by a wide cast of volunteer scientists, culminating in a science symposium in which more than 150 students present independent research in a professional format and setting.

Bucks County Vet Science Clinics (Bucks County, Pennsylvania) – The Vet Science Clinics program, formed in 2006, serves youth aged 13 to 18 who have an established interest in veterinary and animal science and have completed beginner and intermediate veterinary science. Youth meet weekly for a period of six weeks and engage in in-depth, hands-on activities while working with a variety of animals.

GEAR-Tech-21, A'ROR'N Bots (Aurora, Nebraska) – GEAR-Tech-21 is a two-year robotics- and GPS-based curriculum, funded by the National Science Foundation. Developed by the University of Nebraska-Lincoln, the program is designed to be implemented as a stand-alone club or as a club offered within an afterschool program. A'ROR'N Bots, a club that meets weekly at the Edgerton Explorit Center, serves ten participants. In addition to using activities from the GEAR-Tech-21 curriculum, the club competes in annual *FIRST* LEGO League competitions.

4-H Great Lakes & Natural Resources Camp (Michigan) – The 4-H Great Lakes & Natural Resources Camp is a seven-day camp set on an inland lake near the shore of Lake Huron. Youth from across the state of Michigan, ages 13-15, participate in daily in-depth sessions on topics related to environmental science and natural resources led by science and youth development experts. Youth also participate in leadership and recreation activities during the camp.

Langston Community 4-H SET Team (Langston, Oklahoma) – The Langston Science, Engineering, and Technology (SET) Team is a club hosted at the Langston University campus. The program meets on alternating Saturdays during the school year and includes a one-month summer session. Targeting youth from the surrounding rural community, the program exposes youth to a wide range of science and engineering fields through hands-on activities led by science content experts.

Promising 4-H Science Programs (continued)

Montana Sustainable Communities Project, Pretty Eagle (St. Xavier, Montana) – The Montana Sustainable Communities Project seeks to introduce youth to science through hands-on activities in robotics, water conservation, and filmmaking. At Pretty Eagle, a Catholic school located on a Native American reservation, program staff lead activities once per month from October to May with support from classroom teachers and afterschool facilitators. This program is funded by a Children, Youth, and Families at Risk (CYFAR) grant.

Rutgers 4-H Summer Science Program (New Jersey) – The Rutgers Summer Science Program, a weeklong camp hosted at Rutgers University, serves high school-aged youth, the majority of whom come from groups underrepresented in science fields. Participants live on campus for the duration of the camp and attend science-related seminars led by campus faculty. Youth also participate in a field trip that emphasizes the real-world application of science. The camp culminates in a poster session at which youth give presentations on issues they have explored during the camp.

Texas 4-H Technology Team (Texas) – The Texas Technology Team is a state-level leadership team comprising 12-18 youth, ages 14-20. The program recruits current 4-H members with an established interest in technology. Throughout the year, team members receive training or conduct independent research on technology-related issues. Members present their research in regional, state, and national forums.

In the following sections of this report, we describe practices and examples from these promising programs within eight domains, starting with Youth Outreach and Recruitment and concluding with Program Sustainability and Scale-Up.

Youth Outreach and Recruitment

The eight programs studied have had little trouble enrolling enough youth to meet their program's capacity. They did not have to invest heavily in recruitment, but they did use some noteworthy strategies to enroll youth from specific demographics and to broaden their pools of possible participants.

Promote recruitment through "word of mouth"

> *[The students] have been recruiting for us, whether formally or informally. They've been talking to other kids. The first year, no one knew about [the program] and, now, we're getting calls.*
>
> **– Lead Staff Member**

Among the programs featured in this report, program directors and staff frequently mentioned word-of-mouth advertising as a strategy to recruit participants. Program directors and staff said that encouraging youth and parents to tell others about the program was an efficient way to broaden the pool of applicants and attract applicants who may be a good fit for their programs. They also advertise programs informally through their conversations with potential participants.

In addition to informal conversations, directors reported advertising their programs in person at 4-H events and through existing 4-H networks. For example, one adult advisor who worked with the Texas 4-H Technology Team described how she spread the word about the team at statewide 4-H events: "We promote it at the State Roundup […]. We go across the stage and introduce ourselves and let them know who we are." She also explained that she personally emailed every 4-H agent in Texas notifying them of upcoming Technology Team application deadlines. "That's why we get more applications than we've ever had," she concluded.

Invite participants to contribute to the recruiting process

Programs may improve their reach by inviting past and experienced current participants to contribute to the recruiting process; this practice is particularly useful when attempting to recruit youth who may be new to the 4-H program model.

The Rutgers Summer Science Program received more applications because of word-of-mouth advertising, particularly through the formal and informal recruiting led by previous participants. In several counties that the program serves, veteran participants have shared their experiences with their peers, helping the program become better-known among community members. Rutgers program staff also told us that using existing 4-H structures to support marketing by previous participants was a successful strategy. In one county, for example, the 4-H Ambassador Program supported youth involvement in the program after they aged out. These 4-H Ambassadors in this county gave presentations during meetings of local teen groups and community organizations to connect with youth and share their experiences in the 4-H science program.

The Texas 4-H Technology Team, which is composed of youth with advanced technological skills, relies on its members not only to help identify potential members with the necessary skills, but also to consider applications and decide who will be accepted onto the team.

Recruit youth through partner organizations

4-H science programs often partner with organizations whose networks include youth or their parents. AIS has established several long-term partnerships with local organizations that host programming. In addition to marketing the program through word-of-mouth advertising and in local newspapers, the program has advertised activities at each of its host sites, such as through organizational newsletters and bulletin board postings. As a result, the program enrolls children whose parents are employees of the host organizations. We were told that the longstanding partnerships with these organizations and the continued interest of these families have contributed to high retention rates among participants.

Design the application and acceptance process to build the desired participant group profile

While some programs have a *pro-forma* application process and accept all applicants, several promising programs in this study find benefits in an application process that incorporates some selectivity and criteria for membership. Depending on their objectives, programs that primarily serve older youth may benefit from an application process that selects youth with a demonstrated interest in STEM and a commitment to the program.

The Texas 4-H Technology Team, for example, uses a rigorous application process that assesses applicant skills, interests, and commitment. New applicants must submit letters of recommendation, three essays on leadership, and examples of their technology-related work. They also submit a creative video essay. Returning participants must submit a modified application each year that asks them to describe their successes with the project in the previous year. Selection of all new and returning members is done by a committee of youth and adults who discuss applicants through video conference calls. They assess applicants using specific criteria to determine how well each applicant would fit into the team, including maturity, leadership, 4-H experience, and of course, technological skills. The application process itself is an opportunity for applicants and selection committee members to develop useful life and career skills.

Other programs set parameters for the numbers and types of youth that are accepted. 4-H Great Lakes & Natural Resources Camp primarily uses a “first-come, first-served” application process with the intention of accepting all who express an interest in learning more about environmental science and natural resources in Michigan. That being said, the directors also believe it is important to be strategic in designing the make-up of the participant group, so as to include a diverse group of youth and increase the chances for youth who may not apply to the program until later. They set enrollment limits for particular sub-groups, balancing participant candidates based on gender, previous participation in the camp, and 4-H club participation. The

program manages the acceptance process through iterative cycles of assessing sub-group numbers and sending out waves of acceptance letters throughout each spring.

Design strategies to recruit underrepresented youth

One desired outcome of the 4-H Science Initiative is to increase diversity in science fields by sparking the interest of girls and of youth from racial and ethnic groups that are underrepresented in these fields. Previous studies of 4-H implementation have found that although few state leaders and county agents set explicit goals to increase the numbers of underrepresented youth in science fields, some 4-H science programs use strategies to engage underrepresented populations (LaFleur, Sanzone, Butler, & Mielke, 2010; Mielke & Sanzone, 2012).

> *I think it's really important, especially for the younger girls to see an older female scientist as a role model. Because I know looking back, I had those in my life and my parents pushed me too.*
>
> **– Volunteer Scientist**

One productive strategy used by two promising programs is to forge strong partnerships with schools or other organizations whose populations are underrepresented in science careers. Through ongoing partnerships with several schools, the Rutgers Summer Science Program has recruited heavily from underserved urban communities surrounding the university. The county extension agents in two counties are very active in the communities they serve and have developed relationships with schools and science coordinators. Where partnerships exist, the county agents have advertised the program and received recommendations from science teachers about specific youth to target for recruitment. The program has also emphasized recruiting volunteers who are representative of the backgrounds of the youth enrolled in the program. In doing so, the program directors hope that youth perceptions of scientists will change and that they will feel welcome and included in science fields.

As required by its CYFAR grant, the Montana Sustainable Communities Project establishes partnerships in communities with underserved populations of youth. Early in the program's design, its leaders partnered with schools in these communities, including the rural Pretty Eagle Catholic Academy, which has large proportions of poor and Native American students. Of the schools and communities that expressed interest, Pretty Eagle was chosen because of the substantial interest of the school staff and the existing afterschool infrastructure that the school had to support the program. The Pretty Eagle program draws all its youth participants from the school. By incorporating school staff into the delivery model, the program laid the groundwork for its continuation in this particular school after the CYFAR grant is finished.

Target parents as part of the program's recruitment and application procedures

Parents can play an active role in science programs, and program leadership can bolster parent engagement by including them in the program's strategies for recruiting and enrolling

participants. Programs may have more success in engaging parents if parents are brought on board early and understand that their involvement is built into their program's design.

AIS parents expect to be involved in the program from the time they sign the application, and the program itself is designed with the assumption that parents will help. When youth participants register, for example, their parents commit to 15 volunteer hours during the program year. Parents are asked to identify any science expertise, and program staff often recruit them to lead sessions. Because many parents are scientists themselves, the program is able to offer a great number, variety, and depth of science sessions. Parent volunteers who lead sessions also serve as role models and resources for a broad range of science disciplines and careers.

However, non-scientist parents at AIS also understand from the application that they will be called on for help. During our observation of a typical Saturday morning, there was approximately one parent for every two youth in each session. Parents serve during sessions as an additional adult presence to help the flow of activities and were seen moving tables, redirecting distracted youth, helping with attendance sign-in, and modeling an authentic interest in the activities at hand. On a day in which some 200 youth launched rockets, parents were instrumental in helping to manage logistical and safety challenges. At the end of a Saturday session, one deaf parent led a 15-minute discussion with youth about her experiences and about overcoming challenges.

Staff and Science Volunteers

4-H programs depend heavily on the contributions of both staff and volunteers, and science programs need expertise in both science and youth development. While 4-H has traditionally excelled in its youth development capacities, about half of 4-H county agents have said that finding science content experts was a major challenge (53 percent; Mielke & Sanzone, 2012). The programs in this study have grappled with this challenge and learned lessons about the how and why of involving individuals with science backgrounds.

Include science experts as site leaders and advisors

Promising 4-H science programs are often led by staff with science-focused interests, backgrounds, and roles. These types of individuals provide perspectives, content knowledge, and connections that firmly ground their programs in science. In some of the programs visited for this study, the program's leader had experience in science or science education; in others science professionals took part in program planning and implementation. For instance, the GEAR-Tech-21 club leader has a doctorate in agricultural engineering, the Texas 4-H Technology Team leadership includes technology industry professionals, AIS's site leadership and board of directors are composed mostly of scientists from industry and federal agencies, and the Rutgers Summer Science Program is co-led by a marine science educator.

Benefits of Leaders with Science Backgrounds

Lead staff members and advisors with a background in science can provide:

- A passionate and consistent focus on inquiry and real-world applications of science
- Access to networks of science volunteers and resources
- Informed guidance and feedback on science activities delivered by volunteers
- Insights on science careers and pipelines

Recruit scientist volunteers to deliver the science content they know and love

The central role of scientist volunteers was an important feature of program models we studied. In fact, six of the eight programs drew heavily on science experts for the delivery and development of content. While youth-development experts can integrate science curricula into a youth development approach, volunteers with deep scientific backgrounds and professional perspectives can provide an authentic window into the practice of science. In addition to delivering content that is conceptually sound, scientists may be especially able to show why the science is exciting and important in the real world. As an AIS volunteer explained, "[All our

These kids get to experience the passion of science. Mine jump out of bed on Saturday morning to get here early. [This program] is different because of the scientists. They pass on their love of learning about science to the kids, which some don't get in their school classes. Here it is all about the play of the mind and building new ways of thinking, building new highways in their minds.

– Parent

educators] have professional expertise in a scientific area. This is a key aspect and its importance cannot be overemphasized….They know and live this stuff and are passionate about it." (For additional discussion of the delivery of science content by volunteer scientists, see the section below, "Science Curricula and Pedagogy.")

Maximize the expertise of youth development staff and volunteers and clarify their roles alongside scientists

Most science experts do not have deep expertise in youth development and can benefit from the support of those who do. In the programs we visited, 4-H county staff played a critical role in establishing the goals of the program – such as developing leadership skills and an interest in science careers – and promoting the pedagogical practices and activities that enable youth to realize those goals. Extension agents can take an active role in providing formal and informal guidance to volunteers.

The 4-H Great Lakes & Natural Resources Camp has institutionalized guidance on youth development and the role of youth development volunteers, whom it recruits from the statewide 4-H extension network. In its formal policy manual, the camp includes formal job descriptions that delineate responsibilities. For instance, program coordinators are tasked with assisting science instructors in the development of lesson plans, which they submit prior to the camp's start. During the camp's morning instructional sessions, youth development volunteers are matched with science volunteers to provide support as needed. Counselor-selection criteria favor past campers who are now pursuing science interests. Counselors are given youth development training and are formally expected to help current campers develop leadership skills.

In several other programs, a youth development expert teamed up with science volunteers to give them support during an activity and feedback afterward. The Langston 4-H SET Team director, an extension agent with a science background, helps volunteers make their activities more hands-on, accessible, and engaging to youth. One long-time volunteer scientist from the club said he has changed how he conducts activities with youth because of this ongoing feedback, which is given in such a way that the volunteer does not feel threatened or undermined. Likewise, AIS leaders typically are in the room with volunteers, particularly new ones, and are prepared to assist during the activity in any capacity – preparing materials, prompting youth inquiry during discussion, or stepping in when youth are confused.

Cast a wide net when recruiting science experts, then tap the specific expertise needed

Given the variety of volunteers and programs we encountered, "science experts" need not be narrowly defined to include only university and lab scientists. Staff and volunteers who lead programs can recruit from a wide range of businesses and other organizations in their locale and identify individuals whose knowledge ranges across many fields of science, engineering, and technology. Volunteer recruitment must of course be strategic and driven by a program's mission and design; however, it may be useful to map the human resources available to the program and think creatively about how the resources could fit into the program model.

Sources of Science Volunteers

Think broadly about volunteers who can promote science learning, looking outside the usual confines of university science education departments. For instance, also consider the following sources:

- Federal agencies with local presence (e.g., USDA, CDC, military, EPA, Army Corps of Engineers, NASA)
- State and local agencies (e.g., forestry and wildlife, environmental testing, water treatment plants, forensic groups)
- Graduate students (e.g., student chapters of science associations, departments with service requirements)
- Large corporations (e.g., aerospace and defense, biotechnology, chemical products, manufacturing)
- Local business (e.g., health providers, mechanics, technology companies, electrical engineers)
- Participants' parents with science expertise

The Texas 4-H Technology Team is driven to search out expertise based on the interests of its members. Because it operates virtually for most of the year, it can draw on adult leaders who live in different cities and have different skill sets and perspectives. Advisors include county and state 4-H extension agents, a Hewlett-Packard manager, and a university-based software developer. The program also draws on the experience of long-time participants who are university students majoring in STEM fields. Additionally, the team taps technology experts as needed for that year's agreed-upon topics, including experts from technology vendors and within the team itself from youth and adult members with specific tech expertise. Similarly, the Langston 4-H SET Team program director works with youth to determine topics for program content and then seeks out the experts who can address those topics.

Recruit scientists through networks and perpetually tend to the relationships in those networks

A couple of program directors agreed that it helps to develop and recruit from their own informal networks. County extension agents who lead the Langston 4-H SET Team and Vet Science Clinics programs are well situated to make connections and continuously build their pool of potential volunteers. Over time they have developed many relationships within their land grant universities (LGUs) and other local organizations. When asked how he recruits volunteers to lead and host activities, the Vet Science Clinics director stated simply, "I just call them up and ask." The lesson here may be that volunteer recruitment is made easier when leaders have already made a concerted and successful effort to establish and maintain the relationships that compose their informal networks.

Recruiting efforts can also benefit from tapping into existing organizational networks and institutionalizing a volunteer feeder pipeline. The 4-H Great Lakes & Natural Resources Camp includes sessions led by volunteers whose natural resource and science expertise comes from several partner entities – two Michigan State University departments, Michigan Sea Grant Extension, National Oceanic and Atmospheric Administration, Michigan Department of Natural Resources, U.S. Fish and Wildlife Service, National Marine Sanctuary, and community-based conservation organizations. The camp leaders have developed formal ongoing partnerships with

these organizations, and many volunteers come as part of their work or school requirements. For instance, the Michigan State degree programs expect students to do outreach and community service, and the camp has become a popular avenue for graduate students to volunteer as scientists. Likewise, the camp recruits career scientists from other organizations by highlighting the outreach opportunities.

AIS has the advantage of being housed at large organizations with deep pools of potential volunteer science experts – the National Institutes of Health, National Institute for Standards and Technology (NIST), and Lockheed-Martin – and the organization does utilize these human resources. Nevertheless, AIS leaders said that their biggest challenge, on which the program's success hinges, is recruiting enough volunteers to carry out the program's design. Offering more than 70 sessions over 19 Saturdays each year, the NIST site needs to fill about 50 session slots with volunteer scientists. Thus, volunteer recruitment is an ongoing year-round endeavor that requires persistence and creativity. AIS site leaders maintain contact with volunteers from past years, but much of the recruiting is done informally by seizing opportunities when they present themselves. One leader gave an example of his recruiting strategy: "The other day I was outside preparing for a lesson by testing harmonics against a stone wall, and some guy walking by asked what I was doing. By the time we got done talking, he was considering doing a session in a couple of weeks."

Look for scientist volunteers who work well with youth

Although many leaders said science experts were at the core of their program model, they were also quick to point out that not all volunteers are well prepared to facilitate positive experiences for youth. Some well-intentioned volunteers may have trouble engaging youth, managing distractions, improvising, or leading desired types of instructional activities, such as inquiry, discussion, and collaborative work.

Strategies for Recruiting and Retaining Volunteers

- Prioritize and plan efforts to recruit expertise in science, perhaps developing recruiting materials and talking points
- Do not underestimate qualities related to connecting to youth, presentation skills, and passion
- Cast a wide net and think broadly about worthy expertise in science
- Make it easy to say "yes" by minimizing burden and providing the right types and amounts of guidance
- Maintain a simple database of past and potential volunteers that includes areas of expertise and notes on past lessons
- Join existing local networks that include people with scientific expertise
- Connect regularly with outreach and public relations divisions in scientific industries and organizations
- Celebrate volunteer contributions within the program community, as well as with the broader public

It is difficult to pinpoint the traits and dispositions that will lead to successful lessons, but staff and volunteers who lead programs may nevertheless want to identify the qualities that work with their youth population and find ways to determine beforehand who may be a good fit. When talking to potential volunteers, the director of the Langston 4-H SET Team assesses not only their expertise on a particular topic, but their commitment to working with youth, saying, "If the child feels like you're just there but you don't really want to be there, that makes a difference." One AIS strategy is to first have volunteers lead a smaller portion of an activity or work informally with youth on the side, during which the site manager and the volunteer can assess if it is a good fit. The Montana Sustainable Communities Project set out to hire university students with qualifications that included the ability to work with youth. With volunteers from universities or informal science education organizations, program directors might tap their contacts to solicit recommendations for potential activity leaders. Ultimately, the best course may be to help volunteers improve their practice and hold on to the good ones.

> *Inspiration. I have the opportunity to inspire children to follow the directions they choose.*
>
> **– Volunteer Scientist**

Consider partnering with K-12 teachers and schools

Teachers can contribute to a program's capacities in instructional methods and in youth development. While the approach and purpose of 4-H science programs differ from school science courses, and teachers are often not interested in volunteering, we have seen a successful partnership and believe there is potential in the model. The Montana Sustainable Communities Project draws on the capacities and roles of partners from Pretty Eagle Catholic School and Montana State University. These teachers have been integral in developing the structure of the program, delivering content during and after school, and planning for sustainability after the program's CYFAR grant ends. One important contribution the teachers bring is the integration of program work into a curricular scope and sequence that enables youth to learn concepts deeply and over time.

Staff of the Montana Sustainable Communities Project discussed other benefits of collaborating with classroom teachers, particularly in the context of youth development. One leader, for example, explained, "Teachers are huge…That's what their passion is: they know how to work with kids." A unique aspect of the relationship between program staff and teachers at Pretty Eagle is developing a cultural context for activities. For example, school staff suggested modifying the build plans for one robotics activity to reflect the associations with an animal in Crow legends. The program staff member explained, "[The school administration] has been very good at working with me. I didn't expect that. I expected to always be an outsider…but the common goal was there – which is to help the kids." (For more information on partnering with K-12 schools, see the "Partner Organizations and Resource Support" section below.)

Professional Development

Not surprisingly, an overarching challenge for programs is finding time for professional development. Volunteers, as well as staff, often struggle to find time and schedule flexibility needed for learning how to better carry out their roles. Mielke and Sanzone (2012) found that 70 percent of 4-H county agents say it is a major challenge to find time for staff and volunteers to attend training. Program directors also may find it difficult to carve out time to develop materials and deliver training.

Although formal, long-term professional development did not feature prominently in discussions, several programs included in the case study offered informal training and guidance to program staff members and volunteers.

Make it easy to access and use professional development

Promising programs in this study approached professional development in different ways. One cross-cutting lesson that emerged from program visits is to develop training materials and delivery that minimize burden on staff and volunteers and maximize the uptake of the most essential content. Some programs developed user-friendly materials that provide practical guidance and can be accessed by volunteers on their own time. These materials can range from Rutgers Summer Science Program's one-page guide for scientists on delivering lessons, to GEAR-Tech-21's curriculum-aligned educator guide.

Program directors also found it time-efficient and effective to provide "on-the-job" feedback and modeling to volunteers and staff. At several programs, including the Langston 4-H SET Team and AIS, program directors gave new volunteers opportunities to observe strong pedagogy and provided feedback to the volunteers in-the-moment or shortly after an activity. Program directors and volunteers agreed that feedback is useful when it is given supportively.

Provide guidance to science experts on lesson planning, delivery, and youth development

Program staff and volunteers with science-related expertise understand science content, but may need professional development or guidance in order to communicate science to youth in a way that supports youth engagement and learning. Among the programs we visited with access to staff or volunteers with science experience, directors reported offering guidance to staff and volunteers to help them plan lessons with youth-development goals in mind.

At the Langston 4-H SET Team, volunteers receive in-person feedback from the director, who actively encourages and coaches volunteers to help them design hands-on activities for youth. When guiding content experts in delivering activities, the director emphasized the program's learning goals for youth and the role that each volunteer could play in achieving those goals.

The 4-H Great Lakes & Natural Resources Camp provides guidance through a training manual, brief face-to-face training, feedback on lesson plans, and feedback through youth

evaluations of the sessions. Developed by a graduate student, the training manual guides scientists who may not have experience working with youth or delivering inquiry and experiential activities for this age group. The manual describes guiding principles for positive youth development, age-appropriate youth development experiences, and means of fostering character development in youth. Because the manual provides sample lesson plans, session leaders can prepare and submit their own lesson plans for review and feedback prior to camp.

AIS site managers also review lesson plans with science volunteers and offer informal feedback. Sample lesson plans are available on the website, and prospective candidates are often invited to observe experienced session leaders prior to delivery. Feedback on lessons most often focuses on minimizing lecturing and adding opportunities for hands-on engagement.

Provide guidance to educators and youth development experts on science curricula and technology

While teachers and youth developers have skills in working with youth, they may benefit from guidance or training on the particulars of the program. Teachers at Pretty Eagle, for example, attend a one-time training to familiarize themselves with the equipment and software that supports the Montana Sustainable Communities Project's curriculum. Teachers may also refer to a website developed by program staff for additional help. Teacher training will become important once the program transitions to being entirely led by school staff. When asked how training and technical support will affect program sustainability, one leader explained, "I think that we've also provided enough people in the school with the training that they can now train each other."

GEAR-Tech-21's program design anticipates that many club leaders will not have expertise in robotics or geospatial information systems. Thus, they have developed several professional development and resource options that local leaders choose from based on their needs and time. The program's curricular modules provide detailed guidance in a user-friendly layout for each activity, as well as companion educator guides for each module. In terms of training, the program offers online training modules, webinars, and a two-day training program.

Science Curricula and Pedagogy

Research conducted by the study team for this and other studies have found that 4-H science programs cover a wide breadth of disciplines, including traditional 4-H content such as animal science and environmental science, as well as a great deal of newer content such as robotics, engineering, aeronautics, and technology. The 4-H Science Initiative has promoted content delivery that is informed by the initiative's goals and research in science education.

The 4-H Science Ready checklist recommends that science programs provide an experiential approach to learning and use inquiry to foster the natural creativity and curiosity of youth. Together, the checklist and 4-H Science Logic Model promote the use of specific intended science outcomes to guide program content, in terms of youth skills, knowledge, and attitudes. The programs in this study incorporate practices consistent with this vision.

Take advantage of the opportunity to maximize youth-centered delivery

Out-of-school-time and informal science programs such as 4-H have the opportunity to develop programming based on youth needs and interests. Programs have substantial flexibility and a mission to increase youth interest in science, whereas school-based science instruction is often constrained by formal curricula and standards, student: teacher ratios, limited time, and space restrictions.

> *You don't have to be some genius scientist working in a lab for the rest of your life. There are other parts of science… I don't have to be a genius to do science if I love it.*
>
> **– Youth Participant**

Several programs visited for this study focused on youth interests in order to develop programming. For example, the Langston 4-H SET Team and the Texas 4-H Technology Team give youth meaningful roles in selecting topics for investigation. AIS includes an independent project that spans several months in which youth take control of their own learning, behave as scientists, and receive mentorship from practicing scientists. During Saturday sessions, youth at AIS choose from among several concurrent sessions on different topics; activity leaders give a brief presentation on what their group will investigate on that day, and youth learn to make informed choices based on their interests in the topics.

Develop student skills and knowledge through experiential learning and real-world applications of science

Science educators have long harnessed the learning benefits of hands-on activities, and programs such as 4-H are well positioned to magnify and diversify youth learning through experiential learning methods. All the promising programs we studied focused keenly on youth being active participants in their learning and working with the questions, methods, and materials used by professionals in STEM fields. Activities were designed to engage youth both physically and cognitively in investigations and problem-solving. They encouraged reflection on learning

experiences, and the application of knowledge toward real-world, local issues. Often, activities used the same scientific materials and types of data as would professional scientists.

While the activities we observed were overwhelmingly "hands-on," these programs went further and implemented a vision of experiential learning that provided the richest experiences possible. To provide a rich experiential learning environment, staff and volunteers who lead programs could work to define explicitly what experiential learning would look like in the context of their programs' goals and content, and infuse that vision in the planning and delivery of programming.

A promising strategy for incorporating experiential learning is to connect youth with science professionals in a way that opens a window on their daily work life. Youth in the Vet Science Clinics program spend their sessions conducting dissections in animal science laboratories and meeting with practicing animal scientists to learn specific aspects of their work. The director has retained a core group of youth over several years, and therefore designs different hands-on activities each year. Youth described how this program allowed them to go deeper into a scientific topic in a very real way, one of them saying, "It's a different form of science than school science." Whereas the leader and most youth participate in animal clubs and animal science courses, the clinic program enables youth to gain first-hand experience of professional animal science.

A practical description for staff and volunteers:

Experiential learning environments enable youth to learn by doing an authentic task and reflecting on it. 4-H science programs can design opportunities for youth to learn on their own or through engagement with adults. Possible components, to be adopted based on a program's context and purpose, include:

- Focus on real-world problems and settings
- Connection to prior youth knowledge
- Youth ownership of the learning process, outcomes, and next steps
- Use of authentic scientific materials, data, and methods
- Active engagement of body and mind
- Real-world applications and generalizations
- Reflection on and planning of learning

Similarly, the 4-H Great Lakes & Natural Resources Camp features a range of experiential lessons taught by natural resource scientists in a lakeside setting conducive to outdoor investigations. Youth can readily be found knee-deep in water, collecting specimens and scientific data. For example, led by a graduate student from Michigan State and a Michigan State extension agent, youth campers caught fish from a creek by dragging seine nets through the water and by using smaller hand nets. Before taking their sample, youth predicted the types of fish they would find in this particular cool, fresh-water habitat. After taking their sample, youth used a dichotomous key to separate and count the fish by species. The leaders explained how the Department of Natural Resources would use these counts to track fish populations.

Good experiential learning activities also invest time in helping youth recognize the value and authenticity of what they are learning. The Rutgers Summer Science Program included hands-on sessions led by experts, typically professors in science, during which youth explored content through an authentic scientific task. In an anthropology seminar, youth used measurement tools and observations of bone structure to determine the identity of a skeleton. At

the end of the activity, the session leader discussed how anthropology can be broadly applied and discussed specific careers that rely on similar skills. In a session at the 4-H Great Lakes & Natural Resources Camp, a U.S. Fish and Wildlife employee taught youth how to conduct a survey of the number of federally threatened "pitcher's thistle" plants on the lakeshore by using GPS equipment. The data collected by youth were to be used alongside data collected by scientists in a statewide almanac of threatened and endangered species.

Incorporate inquiry in activities

While sometimes challenging pedagogically, activities that incorporate scientific inquiry engage youth in the processes used by scientists and can deepen their learning. Inquiry-based learning is worth the effort required to develop and implement these promising instructional strategies in 4-H programs. Inquiry can look different from one activity to another. For instance, inquiry might be at the core of an activity, such as with citizen science research projects or robotics design challenges. Inquiry may also be injected into activities that use purposeful questioning strategies or prompts. Inquiry may be built into an activity's scientific questions, methods, and intended outcomes.

> *One take-away for kids is to get them to be able to answer scientific questions on their own. So they learn the scientific method: make a guess, test it, and draw conclusions.*
>
> **– Lead Staff Member**

A practical description for staff and volunteers:

Inquiry-based learning environments actively encourage youth to explore and understand content through observation, questioning, and investigation. The National Research Council described core components of inquiry-based learning that can be integrated into activities to help youth develop science abilities.* In these activities, learners:

- are engaged in scientifically oriented questions
- give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions
- formulate explanations from evidence to address scientifically oriented questions
- evaluate their explanations in light of alternative explanations
- communicate and justify their proposed explanations

* National Research Council. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning.* Washington, DC: The National Academies Press, 2000.

Programs visited for this study incorporated inquiry-based learning using different approaches. For example, AIS infuses inquiry into a discussion at the beginning of its Saturday sessions. Prior to breaking into groups for activities, the whole group engages in five to 15 minutes of discussion about recent scientific phenomena and news. These discussions are rich with prompts for youth to develop questions and hypotheses they have about phenomena. Youth are encouraged to respond to each other, supporting, extending, or refuting ideas as they develop. This is not a drawn-out activity, yet it sets the stage for scientific thinking and engagement. Another component of the AIS program is its independent project. Youth develop a scientific hypothesis on a topic of their own choosing, and then design and carry out a test at home

over a couple of months. This occurs largely irrespective of the activities they engage in on Saturdays and is primarily a self-directed investigation.

Robotics and other engineering design challenges, such as those in the GEAR-Tech-21 curriculum, offer an opportunity for youth to apply their own hypotheses and tests as part of the design process. Design challenges often provide some direction, while leaving room for inquiry and innovation. They may pose a plausible problem, set some parameters, and provide enough procedural guidance to set youth off toward their own solutions. Youth must predict, evaluate, and substantiate design trials, and often they are asked to do so in a team.

GEAR-Tech-21 is an example of how a design challenge can be structured to draw out inquiry-based learning. At the heart of the program is a year-long curriculum of weekly activities. Each activity focuses on a specific skill focused on real-world application in robotics and technology. Activities include an open-ended challenge, authentic examples and problems, and practice of the Do-Reflect-Apply design cycle. In the observed program, adult leaders had limited robotics knowledge, which required youth to form and answer their own questions.

Manage a realistic yet productive balance between adaptation and fidelity of an adopted curriculum

Implementation of any curriculum in the field typically undergoes some measure of adaptation. One strategy to balance adaptation and fidelity of implementation is to explicitly identify the curriculum's non-negotiables – in other words, the essential elements of the curriculum which, if removed, would render implementation ineffective. 4-H leaders may want to think strategically about their curriculum's core objectives and the path to get there, given the conditions in which the program is operating. If the essential features of a curriculum are not clear, staff and volunteers who lead programs may want to further clarify and prioritize the features, and then communicate those priorities to staff and volunteers.

The GEAR-Tech-21 club we visited, A'ROR'N Bots, utilized some of the above-mentioned strategies when implementing the GEAR-Tech-21 curriculum. During the school year, GEAR-Tech21 clubs use the program's proprietary curriculum, which was founded on its summer camp curriculum and intended for implementation by volunteer club leaders. Curriculum implementation varies to some extent from club to club, unsurprisingly, given the variations in club leadership, membership, longevity, and educational and developmental priorities. Nevertheless, the curriculum's activities are designed to promote fidelity of implementation for several essential features, even if there is some adaptation around other important aspects (e.g., student grouping patterns, amount of direct instruction, and the role of student leaders). For instance, activities are built on an underlying framework in which youth cycle through a "Do-Reflect-Apply" process that promotes student inquiry. All activities include real-world, hands-on engineering and design challenges relevant to contemporary careers, and all include team-focused exercises and problem-solving. By design, the curriculum promotes these essential features while intentionally leaving room for customization based on club context and need.

Enable volunteer science experts to develop their own curriculum, driven by their expertise and passions

Programs that rely heavily on science experts to lead sessions may benefit from engaging the experts as content developers. Depending on program specifics, the curriculum may range from a one-time session to a unit that spans months. Regardless, science experts willing to volunteer their time are unparalleled resources when they have the support and opportunity to translate their interests and knowledge into rich, youth-centered learning opportunities. The curriculum will be rooted in the volunteer's own deep professional knowledge and love for the topic. And as a practical matter, such an arrangement is more likely to attract and fully engage knowledgeable volunteers who have limited time.

One AIS volunteer who has led several sessions over the past couple of years has developed and refined her lesson plans. She began development with two overarching principles: make the activity "hands-on," and choose a topic her youth would find interesting. Drawing on her own professional expertise, she developed a chicken embryology experiment. She has found that it is important to break the 90-minute activity into several sub-sections to meet youth needs. At the outset, she asks provocative questions and encourages youth to develop their own questions and predictions, and she later returns to reevaluate these questions. She evaluates each aspect of the activity as to whether it serves her goals for youth of having fun with each other, leaving eager to apply and share what they have learned, and being motivated to learn more.

However, science volunteers who are excited to share their knowledge will still likely benefit from assistance in developing activities that are youth-centered and appropriate for a 4-H context. Programs may consider providing formal tools and guidance on lesson planning, student capacities, youth-development strategies, and common pitfalls. They may also want to provide volunteers with opportunities to observe model lessons and to receive individualized feedback on lesson plans, and, afterward, on delivery. For instance, at the 4-H Great Lakes & Natural Resources Camp, volunteers are given a framework that situates the lessons they develop within natural resources and environmental studies and aligns them with state academic standards and Great Lakes Literacy Principles. At AIS, leaders invite potential volunteers to attend sessions, help identify topics that would match volunteer expertise with the broader curricular scope, and troubleshoot lesson plans.

> *I tried to make it so that they don't even know they're learning. Go get in the mud, and don't come out until you find a fish. And when they find out what fish that is, they're not thinking about the fact that they went through a dichotomous key to figure out what that fish was. They're thinking, I just swam through the mud, and this is awesome.*
>
> **– Volunteer Scientist**

Develop content targeted toward participant skills and interests

Two of the programs, the Texas 4-H Technology Team and the Vet Science Clinics, developed advanced content for use in their respective programs. Both programs place a high priority on recruiting youth with strong, pre-existing interests in science and tailoring program

content based on youth skills and prior experiences. Texas 4-H Technology Team participants have established expertise in computers and technology. At the semiannual in-person training sessions, experts deliver highly technical information to youth participants and push their capabilities. Team members are then able to apply their new skills by providing technical assistance and training to other youth and adults.

The Vet Science Clinics shared a similar approach. Youth participating in the clinics are required to complete two preliminary animal science courses to be eligible to participate. The director of the clinics noted that much of the content youth learn through the program is taught in college-level animal science courses. Programs such as these provide youth who are already knowledgeable about a science field with opportunities to explore their interests and deepen their understanding of a career pathway.

Youth Development and Attitudes toward Science

As with all 4-H programs, a key element to a successful 4-H science program is an atmosphere and approach that supports positive youth development. As detailed in the 4-H Science Checklist, science programs are expected to provide youth with opportunities to experience the Essential Elements of Positive Youth Development: mastery (addressing and overcoming challenges), independence, a sense of belonging, and generosity towards others. 4-H science programs are also intended to develop youth interests in science fields, as well as an understanding of science careers and career pathways. This study found promising programs that created positive environments for the development of life skills and a love of science.

Provide opportunities for the development of positive relationships in a science context

4-H programs are intended to provide a safe environment where youth can develop positive relationships with their peers and with adults. The promising science programs in this study focused on positive relationships and did so within and alongside science-related content. Science activities observed at the programs had youth engaged collaboratively in hands-on activities, predicting and evaluating through group discussion, and spending some unstructured social time in a science-oriented setting. There were also opportunities for youth to talk informally with adults about science and non-science topics. In many cases, relationships were built between youth and adult science volunteers who could share their own personal experiences about science careers and pathways to a career, as well as their passion for science.

> *[The program director] is like my 4-H father….There are other 4-H leaders too and they give me advice and they help me with problems that sometimes I'm too embarrassed to ask my parents about.*
>
> **– Youth Participant**

The GEAR-Tech-21 curriculum structures activities to be collaborative design challenges. Youth, who range in age and experience with robotics, work together on teams as part of the program's intentions to develop skills such as collaboration and communication skills. The GEAR-Tech-21 club observed for this study participated in the *FIRST* Lego League competition as a program capstone event. Program staff and volunteers used the competition to promote a strong sense of camaraderie among team members and the importance of the youth supporting every team member's success. The program, as is encouraged by the *FIRST* Lego League materials, emphasized cooperation over competition and a sense of gracious professionalism.

At 4-H Great Lakes & Natural Resources Camp, youth have ample opportunity to develop relationships with scientists, graduate students, and science-focused near-peers in a week-long residential camp. Science experts serve as accessible role models who participate fully in the life of the camp. Their formal job description specifies that they will eat meals with campers, attend campfires, and promote positive youth development. Counselors at the camp are recent camp participants who have an interest in youth development and the natural resources. They accompany the youth throughout the day and night, modeling and counseling positive behaviors.

The leader of the Vet Science Clinics coordinates all agricultural and animal 4-H programs in the county. Most of the youth in the clinics know him from their participation in other clubs, and developed positive youth-adult relationships with him over time. At Langston 4-H SET Team, the director's commitment to youth well-being and the longtime involvement of many science faculty and parent volunteers contributes to a trusting, familial program community. Among the youth and families who participate year-round through the summer program and school-year club, there were strong ongoing friendships.

Structure science activities to promote the development of life skills

4-H Science programs, in addition to teaching science content, are expected to help participants build and improve on a number of life skills, including communication, leadership, critical thinking, and problem solving. To support building these life skills, leaders and volunteers in programs that we visited wove together science with life skill practice. In the Langston 4-H SET Team, staff and volunteers actively try to help youth gain confidence and express themselves. Opportunities for public speaking are included in a number of program activities, including sharing journal entries about what they learned during activities with their peers, and speaking about their 4-H experiences in front of state legislatures and Congress (as delegates to the National 4-H Conference).

> *The ropes course was a type of ice breaker, but more. It was building skills that we need to develop like communication and leadership. You have to apply life skills to complete the challenge.*
>
> **– Youth Participant**

In the Texas 4-H Technology Team, youth are selected for membership based on a combination of their maturity, leadership skills, and interest in technology. Through their participation on the team they gain a variety of life skills such as public speaking, teamwork, problem solving, and leadership. Youth present in front of their peers and at large 4-H events, and work in committees to accomplish team tasks. Participants must learn to be adaptable and problem solve when things don't go according to plan at events, while serving as leaders and representatives of Texas 4-H. Furthermore, participants must complete a significant amount of independent work for their committees and presentations, helping to build time management and self-motivation skills.

Campers at the 4-H Great Lakes & Natural Resources Camp paired up with a partner to plan and deliver a presentation on a science-related topic of their choosing. Throughout the week, each pair met to choose a topic and create a presentation that they would present to an audience of their peers, counselors, and adults. Through this experience, campers developed skills in communication, public speaking, teamwork, and self-efficacy by being able to present a topic of their own choosing. At the conclusion of each presentation, youth and staff in the audience asked questions and provided one item of positive feedback and one item of constructive criticism.

Involve youth in their communities through science projects

One of the goals of the 4-H Science Initiative is that youth will apply their science-related skills to solve everyday problems in their communities. (This goal aligns with the "generosity" essential element of positive youth development.) Programs visited during this study took a project-based approach to youth involvement in communities through science. Through this approach, programs enabled youth to decide how they wanted to make an impact in their community through science.

At the Rutgers Summer Science Program, youth are actively encouraged to consider how they can translate their summer experience into community action. In many counties, youth who have participated in the summer camp have organized after school activities and demonstrations for younger youth in their communities based on the content learned during the summer camp. In other counties, youth have become 4-H ambassadors and have reinvigorated the 4-H presence in their communities.

> *Last night they had a fisheries debate…[The group discussed] things like, "What can you take from this camp and do back in your communities? Start a 4-H club? Become part of the State Youth Conservation Council?" You're here for this week, but you're responsible to go back and do something with it.*
>
> **– Volunteer Scientist**

The Sustainable Communities Project in Montana links art, science, and community engagement through a videography curriculum. Youth learn about film technology and technique as they create a short film on a science-related topic of their choosing, often relating to an issue in their community. During one observed activity, program staff, with support from the classroom teacher, actively worked with youth to select topics and methods to convey information to their audience. Several youth expressed interest in interviewing community members to support the content of their films; a finished film on the chemical and psychological effects of alcohol on teenage girls, for example, features interviews with a leader of a local health organization and college students. A film created by a student in a previous class on coal production featured an interview with state leaders: "We had a girl who worked in the film program, and she and her partners did a video on coal and how coal affects Montana, and, somehow, they finagled an interview with the governor of Montana. […] The kids went up in their business suits and interviewed the governor of Montana about coal development." Student films are also shared with the community, both at school events and at a community day hosted at a local theater.

Efforts to connect science and service can be brief activities embedded into curricula, such as a discussion of contemporary issues using newly gained scientific knowledge. For example, at 4-H Great Lakes & Natural Resources Camp, campers were asked to take sides and discuss polarizing political and natural resource-related issues, including pollution restrictions, private property rights, and the Governor's policy positions. Adults then engaged youth in discussion, asking certain individuals why they held a certain opinion and then providing relevant counterpoints for youth to consider.

Build opportunities for youth to serve in leadership roles

At the Great Lakes & Natural Resource Camp, former campers often return as camp counselors who serve as mentors for current participants. Counselors are selected through an application process and must demonstrate an ability to work as part of a team, make current campers comfortable, and identify how they will use the experience as a counselor in their communities. Counselors serve primarily as support staff, ensuring that the campers are "healthy, safe, and having a good time." Counselors give leadership to camper orientation and each night's campfire activities.

When asked what it is about the Langston 4-H SET Team that keeps them coming back, participants noted the role that they have in teaching younger youth was a draw. For example, older participants enjoyed the control they had in planning and running activities for younger children during Langston University's annual Goat Field Day.

Enable youth to make meaningful choices about what they learn and how they learn it

Research has shown that programs that allow youth to contribute to their experience can help participants to develop increased interest and engagement in science, improved understanding of science contexts, increased self-confidence and feelings of competence in science, and self-reported improvements in academic achievement (Institute for Learning Innovation, 2007). Several programs included in this case study employ a variety of strategies to encourage youth to direct their own learning. Participants in AIS, for example, complete independent projects that encourage youth to explore a scientific question of their choice.

The Sustainable Communities Project at Pretty Eagle aims to spark youth interest in science and develop self-efficacy by allowing youth to explore content through hands-on activities. Older youth in the program are encouraged to explore a scientific topic of their choosing through the videography project. As one teacher at Pretty Eagle explained, the process of filmmaking and the finished projects have become useful companions to science instruction and a strategy to excite students about science.

In the Texas 4-H Technology Team, content is partially driven by youth interest and input. At the fall meeting, the team works together to establish goals for the remainder of the year, which extends through the next summer. This helps the team identify what training they will need to do at the spring meeting. For example, several of the newer members have some experience with robotics and expressed interest in pursuing robotics with the Technology Team, so the team is considering ways to showcase their talents through a demonstration at Texas 4-H Roundup, the statewide 4-H event held each summer. Similarly, each spring the team considers what topics and software to focus on the following year. Participation in the Technology Team also requires a significant amount of independent research and study, which may culminate in a presentation at a local, state, or national forum. At the spring meeting, several team members delivered a very extensive presentation on online safety and social networking. Each of the presenters spent time researching their selected topic, identifying key points, and crafting a slideshow presentation for an audience.

The Langston 4-H SET Team director makes a concerted effort to find out what scientific topics youth in the club are interested in, and to address those topics in team activities. For one of the team's alumni, the director's youth-focused approach helped him on a path towards studying physical therapy: he was interested in science and in particular in physical therapy before joining the team, and told the director of this interest. Topics on anatomy and other scientific topics kept him engaged: "[Before I came to the team] I wanted to be a physical therapist. We talked a lot about that, and so that's another reason why I always came back [to the team.] We talked a lot about science and stuff like that, and how the body works. We used to do little mini-classes, and [the director] would ask each person what we wanted to get out of the class, and we would tell her. And then sometime during the summer we would tie that into everything."

Develop program activities that expose youth to diverse science fields and careers

Within a positive youth development environment, 4-H science programs endeavor to develop youths' interest in science, expose them to new science fields, and help them learn about the education needed to enter those careers. Among the programs visited for this study, leaders and staff implemented strategies to encourage youth to develop an interest in science fields and to expose youth to science-related careers.

Previous research has found that early exposure to science-related careers can encourage youth to pursue science education at the post-secondary level and beyond (Tai et al, 2006).

> *[The club] taught me other things that school wouldn't. I learned about agriculture, anatomy, public speaking, engineering, the gardening. All that transitioned me into nursing because I am a more hands-on person. Somehow it changed my mind, and it was a good change.*
>
> **– Youth Participant**

Several programs included in the case studies are designed to introduce youth to a variety of science fields and careers. The Rutgers Summer Science Program, for example, seeks to introduce youth to a variety of science fields and the ways in which they can engage in science through education and careers. Youth can choose to attend sessions in food science, ocean science, and green engineering led by university faculty. The program also includes a field trip to see science used in a real world context.

The Langston 4-H SET Team designs programming that exposes youth to a variety of different science topics. In explaining why her team addresses a variety of topics instead of focusing on one particular area of science, the director said, "[The children] are very different, and the only way they'll figure out what they want is if we expose them to a variety of fields." In order to introduce the team's youth to this variety of science topics, the director engages many volunteer scientists from in and around Langston University. These scientists not only bring their in-depth knowledge of their fields of study to the club, but also model their careers in science for the team's youth. One longtime volunteer activity leader, a Langston professor, described how he involved participants in monitoring the water quality of a local lake and creek. During the school year, his college students collect data, and during the summer the 4-H team takes over data collection.

> *We want [youth] to get used to fact that science is all around them, not just in classrooms and books or even labs. Life is full of science. And science is something to communicate about and share your thoughts about…We want students to leave with the idea that science is fun, not hard, and to open their eyes to the fact that there is a lot more out there in science than physics, biology, and chemistry, which are the big three topics in schools. There are so many subfields and you can have a career in one that you never even knew was possible.*
>
> **– Lead Staff Member**

Youth in the Vet Science Clinics gain exposure to new careers by working closely alongside volunteers that work in animal-related industries, such as an employee at a sheep birthing facility or faculty and students at Delaware Valley College (which focuses on animal science). The leader wants to expose the participants to new things and help them realize that they don't have to be a farmer or a veterinarian to have a career working with animals. He wants them to know that there are diverse career paths that all related to animal science, such as genetics, chemistry, biology, and physiology.

The Rutgers Summer Science Program emphasizes the science education pipeline by introducing youth to the college environment and making connections between careers and academic studies in science fields. This goal is evident in the program's design, including recruitment targets as well as workshop and activity planning. The camp's leadership is interested in recruiting youth from backgrounds underrepresented in the sciences, especially youth from underserved communities and those who would be the first in their families to attend college.

One Rutgers program staff member explained that recruitment efforts focused on youth who want to attend college but need additional guidance, support, and exposure to take the right steps toward that goal. In addition to science-related activities, youth participants attend a panel on planning for college and undergraduate life, giving youth an opportunity to discuss pursuing higher education with current students and university admissions officers. Workshops and activities are also planned with the goal of helping youth connect to the science education pipeline. Workshop leaders, many of whom are faculty at the university, receive guidance to design sessions that not only expose youth to a scientific issue but also discuss the educational pathways to careers related to the fields. One suggestion featured is to begin workshops with a discussion of the scientist's background. Many discussed their high school and college years, highlighting factors that sparked their interest in their field of study and what motivated them to become scientists.

Partner Organizations and Resource Support

Many 4-H offices and programs establish partnerships with a variety of organizations to support programming with material, financial, and human resource support. The programs visited in this study employed strategies to find partners and to maintain ongoing, mutually beneficial partnerships.

Draw human resources and science expertise from organizational partnerships

Partnerships can provide programs with much-needed human resources, including volunteers with science and youth development expertise, as well as others with knowledge in research, curriculum development, and marketing. For the programs studied, partners include university departments, research laboratories, science-focused grant projects, government agencies, and corporations.

Several programs found that partnerships with STEM departments in LGUs and other universities can create a steady pool of volunteers with science expertise. Langston 4-H, for example, draws many of its volunteers from the university's science community, including faculty and graduate students. 4-H Great Lakes & Natural Resources Camp has established institutional relationships with university departments and state agencies, capitalizing on formal and informal service expectations for graduate students and professionals. Likewise, the Rutgers Summer Science Program has benefited from a partnership with its host LGU that is strengthened by the university's commitment to serving the community through science and helping the program gain willing and enthusiastic participation from faculty.

> *Professional chapters at universities are looking for outreach opportunities and are great resources for recruiting graduate students… We linked up with a student chapter of Mineral Metal Materials Society and are turning to linking the students with a new AIS site.*
>
> **– Lead Staff Member**

Universities and colleges outside of the LGU system can also provide access to content experts, who can embody and speak about career pathways in science. Among the partners of the Vet Science Clinics program is Delaware Valley College, a local college specializing in animal science. The college hosted participants at its swine facility, and youth had the opportunity to learn from experts about swine reproduction. At the college's small animal facility, university professors led activities on the care and use of laboratory animals for research. Undergraduate students at the college served as near-peer human resources, telling youth about their experiences in animal-related degree programs.

AIS leaders said that human resources and expertise are its partners' most important contribution. Site managers and the vast majority of its many science volunteers are employed by AIS's partner organizations, which are governmental (NIST and NIH) and corporate (Lockheed-Martin).

Look for low-cost ways for organizations to partner and make substantive contributions

If potential partners perceive that partnering will bring large or growing costs, they may be reluctant to partner. Yet, low-cost partnerships can offer programs significant benefits through such non-monetary resources as their networks of potential volunteers and participants, scientific and educational cultures, knowledge resources, reputations, and facilities. Programs in this study tended to have partners that shared an interest in the programs' missions, perceived benefits from the relationships, and experienced costs that were relatively minimal and sustainable. Program directors may want to consider the perspectives of current and potential partners and how they might arrange "win-win" relationships.

Strategies for Establishing Strong Sustainable Partnerships

- Find partners with overlapping missions
- Identify individuals in partner organizations who can be internal advocates and decision-makers
- Effectively communicate the potential benefits of partnering, from the partner's perspective, including those related to public relations and organizational identity
- Minimize the costs of partnering and preempt concerns
- Codify partnership agreements and roles, such as in a Memorandum of Understanding
- Develop creative strategies to showcase the program's success and partner contributions
- Create a sense of community and regularly communicate with current and potential partners
- Give tangible evidence of youth outcomes, putting a face on the work

Programs in this study had partners who made essential, yet relatively modest, contributions. A GEAR-Tech-21 chapter in Nebraska benefits from a partnership with a local science museum, established through the director's personal network. Through this partnership, the program has found a physical location for meetings, and has since received assistance from staff on robotics projects. The Vet Science Clinics program, similarly, receives material support for dissections through partnerships with local slaughterhouses.

AIS leaders emphasized that when recruiting new organizational partners, they highlight the minimal cost and potential benefits. They are primarily interested in meeting space and do not ask for funding support. Ideally, the program would have a closet or locker in which to store materials onsite and perhaps the ability to periodically advertise to volunteers through the organization's newsletter, but otherwise there is little else in the way of cost. Because partners are often concerned about liability, AIS leaders make it clear up front that the 4-H program is insured and that the organization is not liable. In return, hosting the program as a partner allows the organization to meet its goals for community education and public outreach. At all four AIS sites, organizational partners have contributed to the program's sustainability, and currently AIS is in talks with potential partners to begin two new sites.

Consider deeper partnerships with schools

4-H clubs and afterschool programs often occur at schools; however, there may be unrealized opportunities for program-school partnerships that enhance youth learning and interest in science. The Sustainable Communities Project at Pretty Eagle established and

maintains a strong relationship with its host school. The site was selected because of the demographics served and the level of interest and commitment from the school's staff. The school's teachers and administrators are active in all aspects of the program: planning, recruitment, scaling, and content delivery. While the program staff may suggest activities or curricula, the school's staff makes all major decisions. According to program staff, institutional support and access to passionate adults with youth development experience has supported the program's mission and content delivery.

Ongoing professional development and support from the program's staff has encouraged teachers to integrate the program's modules into the school's curriculum. Between program sessions, the teachers sustain program work by pulling robotics and other curriculum into their classroom lessons and afterschool activities. At the beginning of the school year, teachers received training to use the curriculum and supporting materials, and the program's staff helped secure activity materials for classroom use. As designed, the program sustainability plan will have teachers take over program management after its CYFAR grant is completed.

> *I found that [the film project] was an extremely good way to get kids psyched about science, way better than the textbook approach. If you can say "Here's what we are going to work on, here's the camera, go for it" and just offer a little guidance, it tends to be a great way for kids to learn science.*
>
> **– Teacher Partner**

Approach partnership development mindfully and persistently

The promising programs in this study spoke highly and thankfully of their partner organizations and individuals, agreeing that the partners were essential for program success. They also worked hard to establish strong partnerships and tend to them regularly through formal and informal communication.

Program Evaluation

Evaluations of individual 4-H programs are often conducted for the purposes of satisfying grant requirements and providing sufficient evidence that program funds were well spent, or in order to guide programming decisions (Mielke & Sanzone, 2012). Through evaluations, staff and volunteers leading 4-H science programs can not only fulfill requirements, but also analyze the effectiveness of particular parts of their programs. By documenting their program's impacts on youth and tracing these impacts back to particular program practices, staff and volunteers can use evaluation results to improve their programs. Evaluation data can also be useful for securing additional funds and increasing program sustainability.

Whether or not it is a grant requirement, design evaluation to provide data that are useful for securing additional funds, partners, and visibility

Evaluations can provide useful summative data for purposes of program sustainability and scaling. Particular kinds of data can be convincing for different audiences. Certain evaluation data can be used to apply for additional funds or program distinctions. Data can also be used to attract partner organizations and enable programs to enter new communities and networks. Evidence from evaluations can also make it easier for journalists, researchers, and advocates to promote the program's visibility.

4-H educators should strategically design evaluations by identifying appropriate performance indicators and giving careful thought to how the data will be used. A useful first step may be to develop a logic model that identifies program contributions (youth, staff and volunteers, resources), program processes (staff and volunteer training, activities), and outcomes (youth attitudes, youth knowledge, and youth development). With clarity and consensus on what the program hopes to achieve and how, leaders can find or develop useful measures of program implementation and outcomes. For example, structured observations of volunteers might indicate ways in which training could be improved.

Evaluation data can also provide evidence of impact on youth outcomes, such as increased interest in science and career pathways, improved content knowledge, enrollment in science classes, and college attendance. Likewise, evaluations can be designed to provide evidence on youth development indicators, such as those related to leadership, collaboration, and positive relationships with other youth and adults.

The GEAR-Tech-21 program requires that all youth participants and adult facilitators complete a pre-and post-survey. The youth survey allows GEAR-Tech-21 to capture an increase in learning of 21st century and STEM skills. Through the use of an established evaluation plan, GEAR-Tech-21 has been able to use their findings to secure funding, find partners, and show the impact of the program. This portion of the evaluation also contributed to GEAR-Tech-21's ability to scale up the curriculum. The evidence of positive impacts on youth that GEAR-Tech-21 obtained through evaluation led to a successful partnership between GEAR-Tech-21 and Time Warner Cable. This partnership resulted in the introduction of the *FIRST* LEGO League

competition to Nebraska. The documentary coverage of that experience expanded the visibility of the program to youth serving agencies and other partners.

In addition to the youth survey, GEAR-Tech-21 program facilitators complete a pre-and post-survey to build their confidence in administering program content and working with youth in STEM areas. The findings from the facilitator survey are then used to strengthen and shape professional development trainings.

Types of Survey Data for 4-H Programs

While surveys should be focused on specific measures of interest and be as brief as possible, programs may want to consider asking questions that generate evidence of a program's impacts on youth, as well as information to improve future programming:

Evidence of impact:

- Attitudes toward science disciplines
- Interest in and understanding of science careers and pathways
- Interest in college enrollment
- Content knowledge
- Youth development skills (leadership, communication, collaboration, initiative, problem solving)

Information for program improvement:

- Topics of interest to youth
- Engagement
- Ratings of specific activities
- Ratings of program environment
- Recommendations for changes

Since 1999, the 4-H Great Lakes & Natural Resources Camp has conducted evaluations that proved useful in its application for 4-H Programs of Distinction recognition. Through pre- and post- surveys, the program has measured change in youths' content knowledge, attitudes toward science, and feelings of attachment and belonging. The program's directors have kept many of the survey items the same to allow for longitudinal analysis, though they regularly consider whether each item is still useful. After adding college interest and readiness questions, directors met to discuss ways to modify the existing survey to better measure life skills and keep the survey at a manageable length.

When asked what types of evaluation data have proven most useful, a 4-H Great Lakes & Natural Resources Camp program director pointed to data on several topics: aquatic science literacy, appreciation and stewardship of natural resources, interest in science careers, youth development skills that enable youth to enroll and be successful in college, and participant intention to stay in Michigan, a state experiencing acute "brain drain." Because these topics align well with the program's goals, the data have enabled directors to analyze the program's progress toward those goals. The program is currently using the National Student Clearinghouse Database to track participant enrollment in higher education programs throughout the U.S and compare their enrollment to state and national college attendance rates.

A recent survey of 4-H county agents found that of those who evaluated science programming in their counties, most agents reported developing their own evaluation tools at least to some extent (62 percent), or working with a state extension office to conduct evaluations (56 percent) (Mielke & Sanzone, 2012). Few county agents who evaluated their science programs reported using evaluators from other organizations (13 percent).

Design evaluations to target program needs and guide continuous improvement

Although it takes time and requires expertise, evaluation can yield information and feedback to drive improvement in program policy and practice. A few programs visited for this study described using data for formative purposes. The Montana Sustainable Communities Project conducted a program evaluation, required as part of its CYFAR grant, that included student assessments, observations, and interviews. With a better understanding of the youth that they serve – including how they learn and what topics are most important to them – the program staff adjusted the program's structure and content. The lead staff member explained, "As you observe and you take notes, you hear what the kids are saying, so then you can tweak things along the way."

Resources for 4-H Science Program Evaluation

Afterschool Evaluation 101: How to Evaluate an Expanded Learning Program* (Harvard Family Research Project, www.hfrp.org) *Developed by the Harvard Family Research Project, this resource provides guidance for program directors on designing an evaluation strategy, collecting data, and analyzing results.*

CYFERnetSEARCH.org Common Measures (www.cyfernetsearch.org) *In support of the Children, Youth, and Families At Risk initiative, funded by USDA-NIFA, this website is designed to build the evaluation capacity of directors, practitioners, and evaluators. The Common Measures are a set of survey instruments selected for use in CYFAR-funded and other programs to measure program outcomes.*

Assessment Tools in Informal Science (www.pearweb.org/atis) *Created by the Program in Education, Afterschool and Resiliency (PEAR) and supported by the Noyce Foundation, this website contains a variety of tools for assessing program quality and youth outcomes.*

Youth Engagement, Attitude, and Knowledge Survey (www.cyfernetsearch.org and www.pearweb.org/atis) *This youth survey was developed specifically for 4-H science programs by Policy Studies Associates.*

4-H Science 101 Training Guide (www.4-h.org/resource-library/professional-development-learning/science-training-guides-resources/) *This guide provides activities to help introduce staff and participants to the development, delivery, and assessment of 4-H Science programs.*

Using Evaluation Methods to Promote Continuous Improvement and Accountability in After-School Programs: A Guide‡ (www.policystudies.com) *This guide, sponsored by The After-School Corporation and developed by Policy Studies Associates, outlines key steps that can help program staff design and conduct useful evaluations.*

* Harris, 2011.
‡ Reisner, 2004.

The 4-H Great Lakes & Natural Resources Camp also used evaluation data to make programmatic changes. The program collected structured feedback on individual science sessions. As part of analysis, directors shared the feedback with session leaders, who typically commit to multi-year participation and can use the feedback for subsequent sessions. The program has used youth feedback from the evaluation to revise the program structure, such as

making a maritime history activity a recreational choice rather than a required educational activity in order to ease logistical burden and provide more opportunities to engage in scientific exploration. The program also changed the way youth were grouped for charter boat and night hike activities in order to create more opportunities for youth to develop stronger relationships with their cabin peers.

New and existing programs may want to consider how an evaluation could provide formative information to meet their specific program needs and identify areas for improvement. While evaluation efforts may benefit from the expertise and credibility of outside evaluators, program directors can also improve evaluations they conduct themselves by drawing from available resources on program evaluation, evaluation instruments, and logic modeling. They can also improve the likelihood that evaluation data will be used for improvement by formally planning the process for using data to guide decision making.

Program Sustainability and Scale-Up

Leaders may face challenges in maintaining their program over time, especially in the face of staffing changes. In addition, some leaders may want to expand their program or add more sites. Several of the programs visited for this study provided windows into particular methods and tools that could be useful for 4-H leaders seeking to sustain and potentially scale up their programming.

Improve sustainability and replication by codifying and institutionalizing key program features, such as procedures, content, training, and partner relationships

While funding is often a primary concern for sustainability, it can also be important for programs to ensure that key features are sustained across years and across staff and volunteer changes. One way to sustain a program is to institutionalize the features of the program that enable it to run as desired and make progress toward its goals. Codifying these features into documents improves clarity and consensus, while providing resources to guide implementation from year to year by current and future staff. For instance, promising programs in this study have developed the following types of documents and tools to facilitate sustained implementation:

- Start-up guidance for new sites
- Training materials
- Memoranda of understanding that clarify partnerships
- Curricula
- Frameworks that include targeted state academic standards, lesson planning or activity guides, and compilations of past activities
- Policy and procedure manuals
- Measurement instruments of youth skills, knowledge, and attitudes
- Recruitment and application materials
- Databases of information on science volunteers and partner contacts

Over the years, the 4-H Great Lakes & Natural Resources Camp has made strides in codifying much of its program, allowing it to prepare and coordinate the many varied staff that will converge to deliver a safe and enriching summer camp. In addition to documents that include schedules and promotional material, the program has developed two manuals: a policy and procedure manual and a training manual for staff and volunteers. Although it is required by the state to develop a policy and procedure manual, the program treats this as a living document, fine-tuned annually, that provides detailed guidance for all staff. The policy manual includes detailed job descriptions for 13 roles within the camp, a staffing plan that specifies youth: adult ratios and staff application processes, camp rules, and various safety and activity policies. The camp's training manual focuses heavily on how to work with youth and foster character development, anticipating that many of its camp staff and volunteers are science experts with little background in youth development. It describes guiding principles for positive and age-appropriate youth development experiences, and provides sample lesson plans.

GEAR-Tech-21 is a state program built around a well-designed curriculum and set of resources that is currently being scaled up nationally. While this program is on a larger scale than many 4-H science programs, it does provide insight into how codifying processes and content goes hand-in-hand with efforts to sustain and scale up the program. GEAR-Tech-21's materials give specific guidance to new clubs and camps and are imbued with the essential features of its approach. The curriculum itself includes detailed module activities and worksheets to be implemented over the course of the year, and the scale-up project is intended to result in curriculum for over 300 hours of instruction across two years. The program includes an educator's guide to accompany the curriculum and professional development materials.

Both large and small programs can benefit from efforts to institutionalize key program features. The Texas 4-H Technology Team annually updates a handbook that guides the team's activities, structure, and content for the program year, providing a common reference point for new and long-term members, youth and adult. Itself a collaborative effort that reflects team consensus, the handbook describes expectations for participation, processes for new member recruitment and vetting, key activities, task committees, agreed-upon topics for skill building, and the biographies of all youth and adult members. It has helped institutionalize some processes and roles in a program that is somewhat unstructured and without a standardized planned curriculum.

Plan for sustainability and replication through program and evaluation design

Several programs address program sustainability or replication by design. As Montana Sustainable Communities Project's program design evolved, program staff used strategies to transition control of the program to Pretty Eagle. The school community demonstrated an interest and commitment which gave directors hope that the program would be incorporated into school life during and after the grant. Program directors were encouraged by the school's willingness to modify school day programming to enable program activities.

The GEAR-Tech-21 program design focused on the development of materials that make it easy to sustain and start implementation, as well as on the design of a network of supports to enable implementation in multiple sites statewide, and more recently nationwide. For instance, to facilitate the startup of new clubs, GEAR-Tech-21 has published online guidance, an interactive "Welcome Book," and an equipment list. It has developed camp planning and implementation resources to facilitate summer camps based on the curriculum. While requesting that all youth and adults in the program participate in evaluation, GEAR-Tech-21 provides clubs with the needed resources, including pre- and post-surveys for youth, facilitator pre- and post-surveys focused on professional development, parent consent forms, youth assent forms, and guidance on evaluating their clubs.

As discussed above, well-designed evaluations can produce evidence that garners external support and contributes to sustainability or scale-up. Both the 4-H Great Lakes & Natural Resources Camp and GEAR-Tech-21 use pre- and post-surveys of youth to formally document youth outcomes, which they use to demonstrate the programs' value to existing and potential partners and funders.

Summary

Since 2006, the 4-H Science Initiative has promoted and supported the expansion of opportunities for youth to engage with science, develop science-related interests and plans, and grow as individuals and community members. New 4-H science programs and sites continue to start up and work toward effective delivery of traditional and new 4-H science content. Having begun with 70 nominations of promising 4-H science programs, the study team recognizes that there is an encouraging growth and variety of these programs across the 4-H landscape. Indeed, one might find beneficial insights from many programs, though this report focuses on eight identified as particularly promising.

The practices employed by the eight studied programs are not necessarily sure-fire solutions for other program settings, but they may spark useful reflection and action by 4-H science staff and volunteers. Rooted in the experiences of those closest to program delivery – youth, site-level leaders, staff, volunteers, and parents – this report is intended to promote discussion within programs and at the local level. The table below summarizes the practices of the promising 4-H science programs illustrated in this report.

Summary of Practices by Eight Promising 4-H Science Programs

Youth Outreach and Recruitment:

- Promote recruitment through "word of mouth"
- Invite participants to contribute to the recruiting process
- Recruit youth through partner organizations
- Design the application and acceptance process to build the desired participant group profile
- Design strategies to recruit underrepresented youth
- Target parents as part of the program's recruitment and application procedures

Staff and Science Volunteers:

- Include science experts as site leaders and advisors
- Recruit scientist volunteers to deliver the science content they know and love
- Maximize the expertise of youth development staff and volunteers and clarify their roles alongside scientists
- Cast a wide net when recruiting science experts, then tap the specific expertise needed
- Recruit scientists through networks and perpetually tend to the relationships in those networks
- Look for scientist volunteers who work well with youth
- Consider partnering with K-12 teachers and schools

Professional Development:

- Make it easy to access and use professional development
- Provide guidance to science experts on lesson planning, delivery, and youth development
- Provide guidance to educators and youth development experts on science curricula and technology

Summary of Practices by Eight Promising 4-H Science Programs *(continued)*

Science Curricula and Pedagogy:

- Take advantage of the opportunity to maximize youth-centered delivery
- Develop student skills and knowledge through experiential learning and real-world application of science
- Incorporate inquiry in activities
- Manage a realistic yet productive balance between adaptation and fidelity of an adopted curriculum
- Enable volunteer science experts to develop their own curriculum, driven by their expertise and passions
- Develop content targeted toward participant skills and interests

Youth Development and Attitudes Toward Science:

- Provide opportunities for the development of positive relationships in a science context
- Structure science activities to promote the development of life skills
- Involve youth in their communities through science projects
- Build opportunities for youth to serve in leadership roles
- Enable youth to make meaningful choices about what they learn and how they learn it
- Develop program activities that expose youth to diverse science fields and careers

Partner Organizations and Resource Support:

- Draw human resources and science expertise from organizational partnerships
- Look for low-cost ways for organizations to partner and make substantive contributions
- Consider deeper partnerships with schools
- Approach partnership development mindfully and persistently

Program Evaluation

- Whether or not it is a grant requirement, design evaluation to provide data that are useful for securing additional funds, partners, and visibility
- Design evaluations to target program needs and guide continuous improvement

Program Sustainability and Scale-Up:

- Improve sustainability and replication by codifying and institutionalizing key program features, such as procedures, content, training, and partner relationships
- Plan for sustainability and replication through program and evaluation design

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Appendix A

Program Selection and Data Collection Methods

In order to identify promising 4-H science programs, the study team partnered with 4-H National Headquarters, U.S. Department of Agriculture and National 4-H Council to carry out a structured nomination and selection process. This process began with a nationwide request to the 4-H community to nominate programs for consideration. During the summer of 2011, state 4-H leaders publicized the nomination form, which was posted on the 4-H website, and program directors and club leaders nominated their programs. In order to be considered, programs had to:

- Serve a minimum of 15 youth
- Run for a total of six hours or more
- Involve adults or teens teaching science-related skills and content
- Provide a rich youth development context reflective of 4-H's core principles.

This call for nominations resulted in 70 nominated programs that met the above criteria. The 4-H evaluation partners and the study team then worked together to narrow this list by examining all of the nominated clubs, after-school programs, school enrichment programs, and camps, and comparing them against other programs using the same delivery mode. When comparing programs against one another, the team looked for evidence that the programs had both a strong focus on science and a rich youth development context, reflective of 4-H's core principles. Additionally, the team made an effort to balance the list of programs so that the final group would include:

- All geographic regions
- Communities of different sizes
- A variety of delivery modes and content areas
- Programs serving youth of different ages, and programs targeted specifically at groups who are underrepresented in scientific fields
- Emerging programs that have recently begun, as well as established programs that have been in existence for multiple years.

The study team then conducted phone conversations and document reviews to assemble profiles of all remaining candidates. The interviews focused on gaining information about: (1) the science and youth development goals of the programs, (2) the intentionality of programming and the ways that activities were implemented to meet these goals, and (3) what participants experienced in a typical session. Using these profiles, a committee of 4-H science liaisons and evaluators from different regions worked with the study team to assess the candidates and ensure variation based on the above factors (geographic location, community size, ages and types of youth targeted, delivery mode, program longevity, and content area focus.) Based on the committee's review and discussion, a small group of programs was selected for further assessment.

In summer and fall 2011, the study team and its 4-H partners collected data on these selected programs through further phone interviews and through site visits. Site visits included in-person interviews with leaders and systematic observations of program activities. Study partners determined that eight of the remaining programs were implemented as described and represented a cross-section of 4-H programs.

In spring 2012, the study team collected additional data onsite, using instruments refined through analysis of the data collected thus far. In addition to interviews with lead staff and volunteers and observations, the team collected data through interviews with volunteers, youth, and parents, as well as through review of program documents (e.g., policy manuals, training materials, evaluation reports, applications for funding). Analysis and reporting relied on all data collected between summers 2011 and 2012. For this report, all of the information regarding individual programs has been fact-checked by the lead staff member of each program.

Appendix B

Program Profiles

Adventure in Science
Montgomery County, Maryland

Program Context

Years in operation	35 (22 years as a 4-H partnership)
Total youth served annually	250
Community served	Suburban
Age range of participants	8-14
Target audience	Youth in Montgomery County
Meeting frequency	Saturdays (October to March)
Curricular area(s)	Broad range (e.g., rocketry, engineering, brain anatomy, robotics, geology, biology, optics, embryology)
Lead partners	University of Maryland-College Park, National Institute of Standards and Technology, National Institutes of Health, Lockheed-Martin Corporation, and Urbana Middle School

The 4-H Adventure in Science (AIS) program in Montgomery County, Maryland seeks to expose young people to a wide variety of science and engineering topics through weekly hands-on seminars led by experts in science and engineering fields. AIS aims to provide youth with opportunities to develop an interest in science and build their sense of confidence and enjoyment of science. The program aims to help youth see that science is a part of everyday life and not something to fear. AIS also seeks to build youths' understanding of science careers and career pathways, as well as promote the development of scientific research and presentation skills. As one AIS leader explained, "We want [youth] to get used to fact that science is all around them, not just in classrooms and books or even labs. Life is full of science."

AIS programming occurs on about 18 Saturday mornings from October to March at four different sites, which are all overseen by a board of directors. This board includes site managers and a 4-H educator at the University of Maryland-College Park, Extension Program of Montgomery County, who is responsible for managing registration and coordination across the AIS sites. As of spring 2012, AIS operated at the National Institute of Standards and Technology (NIST), the National Institutes of Health (NIH), Lockheed-Martin Corporation, and Urbana Middle School, and a new site is being added in fall 2012 at Johns Hopkins University-Montgomery County. Each site is run by a volunteer site manager, who recruits volunteer adult teachers to lead hands-on science sessions on Saturday mornings. Session leaders and site managers are typically career scientists who are employees of the four host sites, parents of participants, local scientists, and/or university faculty. With approximately 250 youth participating in the program overall, each site maintains a roster of between 25 to 80 youth. Attendance throughout the year remains high: AIS reports that in a recent program year, 90 percent of participants attended all Saturday classes. From year to year, AIS expects 65 percent of the participants to return.

Promising Practices and Lessons Learned

Encourage youth development and science learning through research and presentation. Parents' Day, the program's culminating event, highlights many of the program's youth development and science goals, such as developing public speaking skills and promoting mastery. Participants take the initiative in identifying their research topic and hypothesis, as well as in conducting and presenting on their research. Students conduct their scientific inquiry largely on their own, but they receive some support in identifying suitable scientific questions and methods. Some sites have also supported students in presentation skills and practice.

The Parents' Day event is modeled after professional science conference in which there are concurrent presentation sessions, each moderated by an adult scientist. Presentations from the 2012 Parents' Day included student-researched topics such as "Papillae and Taste: Do Picky Eaters Taste More?" and "Measurement of Bacterial Contamination in Baby Food." Each presenter addressed an audience including peer researchers, family members, and members of the scientific community. Approximately 400 people attend Parents' Day, including about 150 youth who deliver presentations. The event concludes with a keynote presentation delivered by a distinguished science professional, like a Nobel laureate, who also serves as a role model.

Engage partner organizations strategically. AIS recruits volunteers through its partner organizations, which have deep pools of science experts. Drawing on their own professional expertise and interests, these volunteers develop and deliver their own lessons. AIS has found that volunteers with deep scientific backgrounds and professional perspectives can provide an authentic window into the practice of science. AIS volunteers deliver content that is conceptually sound, while demonstrating the excitement of science and its relevance in the real world.

When recruiting partner organizations, AIS leaders emphasize the minimal cost and potential benefits. They have used an approach that anticipates the organization's concerns, and the AIS model is designed to minimize cost. AIS has also found it important to demonstrate how the partner and program share common interests and how the relationship could result in mutual benefits. AIS partnerships provide organizational partners with opportunities to contribute in a positive way to their community and carry out aspects of their missions. AIS's efforts to recruit partners have included strategic thinking about whom within an organization should be contacted, and persistence in arranging face-to-face meetings. While every organization's decision-making structures are different, AIS has benefitted from targeting organizational leaders, as well as staff responsible for community outreach, public relations, or education. The program has also had success striking up new partnerships by inviting leaders from potential partner organizations to attend Parents' Day.

Provide opportunities for youth to have roles in leadership and community service. Adventurer Assistants is a special AIS program for youth who are 14 or older and long-time AIS participants. Adventurer Assistants support the site managers and session leaders with administrative tasks, but also serve as role models and help facilitate content delivery. In the process, the Assistants develop close relationships with scientists from different disciplines. Candidates must apply and receive training from the 4-H extension educator on how to apply their leadership and community service skills.

Bucks County Vet Science Clinics
Bucks County, Pennsylvania

Program Context

Years in operation	6
Total youth served annually	24
Community served	Rural, suburban, urban
Age range of participants	13-18
Target audience	Youth with established interest in animal science. Youth must complete Animal Science Levels 1 and 2 to be eligible
Meeting frequency	Once a week for six weeks (usually February to April)
Curricular area(s)	Veterinary science
Lead partners	No primary partner, but various one-time or secondary partners

The Bucks County Veterinary Science Clinics is a six-week intensive study open to 4-H youth who have completed beginner and intermediate level Animal Science curricula. The program serves youth ages 13 and older in Bucks County, Pennsylvania, just outside Philadelphia. Each spring, participants meet once a week for six weeks to engage in various activities related to veterinary science, such as animal vaccinations, reproductive cycles, and the use of and care for laboratory animals. The clinics take place on-site at area facilities related to animal care.

The adult leader does not use a predefined curriculum, but rather pieces together lessons and topics using materials from 4-H extension and other online sources. He asks youth to read a brief article about that week's topic before arriving, and asks youth to complete a review worksheet at the end of each activity. Youth participants share a well-established interest in animal science and are very inquisitive about the material covered during the clinics. Through these clinics, participants learn about careers related to animal science by interacting with various industry professionals such as university professors and farmers at a local sheep facility.

Promising Practices and Lessons Learned

Use networks to build and maintain program partnerships. The leader of the clinics is 4-H extension agent in Bucks County, and therefore has access to a large network of 4-H resources nationwide. He uses materials from various extension offices to develop a customized curriculum for the teen participants, which includes articles, diagrams, and worksheets. He also has access to an informal network of local scientists and professionals, with whom he forms partnerships to support the program. Some of these partnerships have been maintained over multiple program years: for example, a local slaughterhouse provides dissection specimens at no cost. The leader also recruits new partners to provide resources and learning opportunities for youth. For example, during the 2011 clinics, Delaware Valley College faculty and students

hosted a small animal workshop, and a local sheep facility gave participants a first-hand look at how to care for ewes and lambs.

Develop content targeted toward participant skills and interests. Vet Science Clinics places a high priority on recruiting youth with strong, pre-existing interests and skills in animal science; youth participating in the clinics are required to complete two preliminary animal science courses to be eligible to participate. As a result, the leader is able to develop more advanced, in-depth content for participants so that they can gain valuable skills and knowledge. While some youth in the clinics also participate in other 4-H activities simultaneously, other youth participate only in the clinics. The leader noted that the advanced content in the clinics keeps the youth engaged in 4-H when they otherwise may have dropped out. According to the leader, exposing youth to in-depth content will give them an advantage over their peers, should they choose to pursue an animal-related career path.

Build skills and knowledge through experiential learning and real-world applications of science. All but one of the six weekly clinics took place at an off-site location related to the care and health of animals. Participants conducted dissections, visited a sheep farm, observed workers at a swine barn, toured a small animal facility, and learned how to administer animal vaccinations at a local farm. Through these field experiences, participants interacted with professionals who routinely worked with and cared for animals. Youth observed the day-to-day work of professionals and animal science students, and even happened to see a sheep go into labor – something they had read about – while at the sheep birthing facility. These types of experiences helped youth to apply their prior knowledge to real-world situations they would encounter in a career working with animals.

Gear-Tech-21, A'ROR'N Bots
Aurora, Nebraska

Program Context

Years in operation	3
Total youth served annually	10
Community served	Rural, suburban
Age range of participants	9-14
Target audience	Youth with established interest in robotics
Meeting frequency	Weekly (October to February)
Curricular area(s)	Robotics
Lead partners	Edgerton Explorit Center, Central Community College

Geospatial and Robotics Technologies for the 21st Century (GEAR-Tech-21) is a national 4-H program which aims to prepare youth for 21st century careers in science, technology, engineering, and mathematics (STEM) through GPS, GIS, and robotics. A'ROR'N Bots, a central Nebraska GEAR-Tech-21 club, is a small club consisting of 10 youth who use LEGO-based robotics kits to learn science, technology, engineering, and mathematics. The club meets once per week and occasionally on Saturdays, starting in October and running through February. Through partnerships with a local science center and community college, the A'ROR'N Bots have access to the necessary facilities, computers, and robotics kits to have a successful club. In the club, parents serve both as volunteers and club leaders and guide youth as they engage in robotics challenges.

At each club meeting, youth work to program their robots to carry out particular tasks that are themed around a variety of real-world engineering challenges associated with the *FIRST* LEGO League (FLL) competition – for example, examining the world's food supply. Youth also prepare for other aspects of the FLL competition, such as the Project component, in which youth explore an actual problem that today's scientists and engineers face and then develop an innovative solution to that problem. The club activities incorporate a great deal of inquiry-based learning: adult leaders possess very little knowledge around robotics themselves, but enable youth to pose and answer their own questions and provide guidance when necessary.

Youth-led club meetings also provide youth with opportunities to gain valuable leadership skills. Youth selected their own leadership roles and were responsible for those duties throughout the year.

Promising Practices and Lessons Learned

Develop skills and knowledge through inquiry-based learning. Through their involvement in FLL, the A'ROR'N Bots were presented with competition challenges, centered

around world food supply issues, which were to be solved through the use of their robots. These engineering challenges required the youth to utilize STEM skills as they designed the programs their robots would follow. Because the youth were the content experts in this club, the club used experiential and inquiry-based approaches to instruction: youth carried out the steps of "do, reflect, and apply" repeatedly in attempts to find solutions to the FLL challenges. Inquiry was a both a necessary and effective style of instruction since the leaders did not have all the answers. The process of prediction, testing, and adjustment that youth used during their robotics challenges was essential to finding solutions to these challenges. During club activities, leaders often responded to youth questions with another question that led youth toward discovering an answer.

Manage balance between adaptation and fidelity of an adopted curriculum. Clubs and camps use the GEAR-Tech-21 curriculum outside of the FLL competition, and in many cases, the curriculum serves as a participant's first introduction to robotics. Many of the original A'ROR'N Bots club members participated in a robotics camp hosted by the Edgerton Explorit Center (a local science center) in which they completed the GEAR-Tech-21 curriculum. This foundational knowledge helped prepare club members for the FLL competition. In this particular area, there are very few STEM programming options available: in fact, youth from neighboring communities travel to take part in the A'ROR'N Bots club.

Engage multiple partners to support programming. Multiple partnerships contribute to the success of this club. The A'ROR'N Bots club is made up in large part from participants in the Edgerton Explorit Center summer robotics camp, and the Center became the club's home location. The Center formed a partnership with a local community college to provide the robotics kits for the program. Another factor in the success of this club is the club leader's strong science, engineering, technology, and mathematics background. Her prior knowledge in these areas helped foster excitement about these topics within the club. The strength of these resources and partnerships is an integral part of this club's success.

4-H Great Lakes & Natural Resources Camp
Michigan

Program Context

Years in operation	29
Total youth served annually	70
Community served	Youth from rural, suburban, and urban areas across Michigan
Age range of participants	13-15
Target audience	No specific youth targeted
Meeting frequency	7-day residential camp during summer
Curricular area(s)	Environmental science, natural resources, environmental stewardship
Lead partners	Michigan State University Fisheries and Wildlife Department, Michigan Sea Grant Program

4-H Great Lakes & Natural Resources Camp is a seven-day residential camp that takes place on the shores of Lake Huron. In existence since the mid-1980s, the camp strives to provide 13-15 year olds with the opportunity to learn about and explore their environment. The content focus of the science is very regional – topics center around the Great Lakes environment, its wildlife, and its resources. Throughout the week-long camp, these science topics are connected with community needs and environmental issues, and youth are encouraged to use what they learn in camp in their communities.

Every day, campers participate in one in-depth session focused on science content (3 hours), one two-hour recreation session that incorporates science learning (e.g. kayaking, shooting sports), and a one-hour leadership session. These camp sessions are facilitated by science and youth development experts from Michigan State University and other regional agencies. The scientists that lead activities are faculty and graduate students from the university, as well experts from outside organizations, such as NOAA, the Michigan Department of Natural Resources, and the U.S. Fish and Wildlife Service. Each content expert co-teaches activities with a person experienced in youth development, often an extension educator. Staff from the university-based Michigan Sea Grant Program and the Fisheries & Wildlife Department are primarily responsible for organizing the science content of the camp and lining up instructional staff; the camp directors are 4-H staff or volunteers and design leadership and youth development activities. Campus-based 4-H staff organize the camp overall.

Promising Practices and Lessons Learned

Recruit volunteers with science expertise. The Great Lakes & Natural Resources Camp includes sessions led by volunteers with natural resource and science expertise who come from several partner entities. Many of the camp's volunteers come as part of their work or school

requirements. As part of the camp's Michigan Sea Grant partnership, Sea Grant staff are expected to do a rotation in which a few staff (3 or 4) come to the camp each year. Within the MSU Fisheries and Wildlife Department, a faculty contact person reaches out to graduate students to recruit them for outreach, which includes opportunities at 4-H Great Lakes & Natural Resources Camp. The director stated that the camp is quite popular with graduate students because "they get a chance to teach what they already know, but they get a chance to learn more from the other Sea Grant experts that are already there."

Offer youth a variety of science topics. The camp features a range of experiential lessons about environmental science, biology, ecology, and natural resources that take place on location, on the shores of Lake Huron, on smaller surrounding lakes and streams, in the forest, and on the lakes themselves. For example, during one morning session observed in 2011, youth went charter fishing on Lake Huron, and in the afternoon, they learned about fish anatomy, ecology, and lake ecosystems through filleting and dissecting the fish they caught. Youth collected the contents of the fish's stomachs, labeled them with information about the fish they came from – where and at what depth it was caught, and its weight and length – and provided their finds to the U.S. Geological Survey Great Lakes Science Center as part of a Lake Huron-wide fisheries food web study.

Promote positive youth development. During the camp, youth are required to attend a set of science content-heavy activities in the morning. In the afternoon, they are free to choose an activity. A counselor at the camp commented, "I've been to other camps and it's more like you have to do this, you have to do that. […] And with this, the afternoon sessions, you can always find something new that you haven't done before. And it's just – it's almost more relaxed, but you still accomplish and gain a lot from the camp."

At camp, youth have ample opportunity to develop meaningful relationships with scientists, graduate students, and science-focused near-peers. Science experts serve as accessible role models who participate fully in the life of the camp. Graduate student and undergraduate students in the sciences lead many camp activities, which gives campers the opportunity to see people somewhat close to their own age (late 20s-30s) who work in science fields. Counselors at the camp are recent camp participants who have an interest in youth development and the natural resources. They accompany the youth throughout the day and night, modeling and counseling positive behaviors.

Evaluate programs to guide continuous improvement. In order to ensure that the camp is meeting its goals, close to 500 campers have been surveyed since 1999. Every year, the camp administers pre- and post- surveys to youth that measure change in science content knowledge and attitudes, and feelings of attachment and belonging. The camp also collects youth feedback and ratings of activities during camp. The camp has received recognition as a Program of Distinction and was able to use these evaluation results in its application. The program is currently using the National Student Clearinghouse Database to track participant enrollment in higher education throughout the U.S and has found that the percentage of program alumni who attend college surpasses the statewide and national attendance rates.

Langston Community 4-H SET Team
Langston, Oklahoma

Program Context

Years in operation	4
Total youth served annually	30
Community served	Rural
Age range of participants	12-18
Target audience	Youth from backgrounds underrepresented in science fields
Meeting frequency	One month of day camp in July; two Saturdays each month during the school year
Curricular area(s)	Agriculture, engineering, food science, animal science, computer science; community service, public speaking
Lead partners	Langston University

The Langston Community 4-H SET Team is a club that addresses a variety of science and engineering content areas, with the goal of exposing youth to a wide range of fields. The director, who is a 4-H extension educator at Langston University, plans and implements activities with the help of science specialists from Langston University, Oklahoma State University, community members and parents, and college student volunteers. The club meets for one month during the summer, and on two Saturdays per month during the school year. The club targets young people from the area's rural community who may or may not already have a strong interest in science. Because the director has strong relationships with the local K-12 school and with community members, the director is able to recruit youth from the school to participate in the club. Since the club has become more well-known throughout the community over the past few years, families and youth now approach the director about becoming members of the club.

The content of club activities is determined based on the director's conversations with current participants, and on feedback from youth in previous years. Activities have included aquaculture, structural engineering, nutrition, circuitry, water quality, and gardening. Once a particular topic is chosen, the director contacts a science professional in that subject area, starting with the agriculture department at Langston and expanding through the university and into the community. If the director cannot find a professional in that field to present material and lead the activity, the director researches the area herself. The director then looks for curricula to use – sometimes using 4-H curricula, and favoring free and low-cost curricula. Then the director adapts the curricula to suit participants' ages and abilities. In addition to science activities, the club also engages in community service activities. The director has a strong youth development focus and works to build participants' communication and life skills.

Promising Practices and Lessons Learned

Recruit scientists that work well with youth. The director recruits volunteer science content experts that lead activities and act as references for the director if she develops activities on her own. The club has many repeat volunteers: some professors from Langston have been working with the club since it began. These scientists not only bring their in-depth knowledge of their fields of study to the club, but also model their careers in science for the club's youth. As one volunteer noted, "Sometimes during our work, I share my personal experiences with them from my youth to where I am in such a way so that they take it as a mirror. I don't get involved in their person lives, but I talk to them about me so that they look at what I did and try to look at me and say he did it. That means I can do it. That's a little bit how I push in their direction."

Spark youth interest in science through a variety of topics. The Langston club director makes a concerted effort to find out what scientific topics youth in the club are interested in, and to address those topics in club activities. The central goal of the program is to expose youth to a variety of scientific topics in order to spark their interest. Part of this also involves addressing young people's anxieties or negative feelings about math and science. In order to achieve these goals, the club works to present science content in engaging, hands-on ways so that youth become interested before they understand that what they are doing falls under the heading of "science."

In the Langston Community 4-H SET team, volunteers and staff actively try to help youth gain confidence and express themselves through their interests. Opportunities for public speaking are included in a number of program activities, including sharing journal entries about their program experience with their peers. These journaling exercises ask youth to reflect on how they could use what they learned at home, at school, and in their community. Youth speak in front of the class on a regular basis, and prepare for presentations at the camp's showcase activity. There are also opportunities for more experienced and knowledgeable students to lead certain activities, including organizing activities for younger youth during the university's annual Goat Field Day.

Montana Sustainable Communities Project, Pretty Eagle St. Xavier, Montana

Program Context

Years in operation	4
Total youth served annually	60
Community served	Rural
Age range of participants	8-14
Target audience	Youth from backgrounds underrepresented in science fields; youth without established interest in science
Meeting frequency	Monthly (October to May)
Curricular area(s)	Environmental science and technology
Lead partners	Montana State University – Bozeman, Pretty Eagle Catholic Academy

The Montana Sustainable Communities project is a community-based program, funded by a Children, Youth, and Families at Risk (CYFAR) grant, that seeks to bring science and technology to at-risk communities in the state. At Pretty Eagle, a private Catholic school, the program serves a majority Native American population in in-school and afterschool settings. Approximately once per month from October to May, program staff from Montana State University (MSU) lead youth in robotics, water quality, or videography activities with support from classroom teachers. Teachers also integrate the robotics and videography curricula into classroom activities throughout the school year. Students may also participate in an after-school component in which they are able to engage in special projects or activities, including the First Lego League Competition.

Activities emphasize youth-centered experiential learning and inquiry. The program uses a Lego-driven platform for robotics activities. Participants in grades 3, 4, and 5 use Lego kits and software to build robots and program simple actions. Videography is offered to students in grades 6, 7, and 8. After learning the principles of film, students develop projects that explore scientific questions of their choice and create three- to five-minute films about these topics.

Promising Practices and Lessons Learned

Establish strong partnerships with host schools. Program staff established and maintain a strong relationship with teachers and administrators at Pretty Eagle. In addition to its demographics, MSU selected this school because of the level of interest and commitment shown by the school staff. Teachers and administrators are active in all aspects of the program, from planning to content delivery. At the start of the school year, the program staff meet with the school's staff to plan activities and discuss the structure of the program for the school year. The site coordinator, a teacher at the school, coordinates communication between program staff and

the school staff; in addition to facilitating communication, the site coordinator alerts program staff to changes in the school's schedule that may impact program activities, coordinates field trips, and helps determine distribution of funding at the site. Constant communication has helped both the program and the school accomplish their shared goals to support academic excellence among the student population.

Integrate 4-H content with classroom activities. Both program staff and day-school teachers deliver content to youth. Professional development and ongoing support from the program's staff has empowered teachers to integrate the program's curricula into classroom activities. Program staff train teachers at the start of the school year to use the curricula and supporting materials. Teachers reported having used elements from the curricula to support math and science lessons by demonstrating how concepts can be applied in real-world scenarios. One teacher described building science lessons around the content that previous students had selected for their independent film projects. "It's an avenue where you can lose the textbook," the teacher explained. During an observed activity in a third grade classroom, students built and programmed robots that represented characters in a storybook they had read during class. As they worked, they practiced reading build plans and using the programming software, and also developed literacy skills as they read along with their teacher.

Implement strategies to sustain programming. Activities at Pretty Eagle have been supported by funding from CYFAR and by staff from Montana State University. At the end of the 2013 school year, the program will transition to be entirely driven by the school's staff. To ensure a smooth transition, program staff and school staff have worked to secure the resources needed to continue program activities. Staff from MSU, for example, have secured computers and other hardware for the school. Current teachers will assume the role of trainers to help new teachers become familiar with the curricula and integrate it with classroom activities.

Rutgers 4-H Summer Science Program
New Jersey

Program Context

Years in operation	4
Total youth served annually	55
Community served	Urban
Age range of participants	14-16
Target audience	Youth underrepresented in science fields
Meeting frequency	One-week residential camp during summer
Curricular area(s)	Varies based on faculty interest
Lead partners	Rutgers University, Tyco

The Rutgers 4-H Summer Science Program is a weeklong camp hosted on the New Brunswick campus of Rutgers University. State and county 4-H extension agents work together to organize the camp. The camp serves youth ages 14-16, and actively recruits participants from groups that are underrepresented in science-related fields. Youth are admitted to the program based on their application, interviews, and recommendations from teachers. Accepted youth live on campus and attend science-related seminars led by university faculty.

Science-related activities aim to introduce youth to the variety of ways they can engage in science. Many seminar leaders structured their seminars to include a discussion of how ideas from their scientific fields can be applied to real-world problems. In addition to science-related activities, the program introduces youth to campus life through interactions with students, seminar leaders, and other faculty members. The program culminates in a poster session at which youth give presentations on issues that they've explored during the camp.

Promising Practices and Lessons Learned

Recruit and support youth from underrepresented backgrounds. 4-H agents who lead the camp have implemented several strategies to recruit youth from backgrounds that are underrepresented in the science fields. The program recruits heavily from several of the state's urban centers, and strives to recruit volunteers who share backgrounds similar to those of participants. One agent explained, "To the best of our ability […] we make sure we at least put people out there that looked like them […] that are representative of them, that are in the pipeline from the Rutgers point of view that can represent their interests and make them even feel more comfortable."

Tap into networks to recruit volunteers with science expertise. The program's campus location and institutional support from university leaders have helped the camp recruit faculty volunteers to lead science seminars. With the support from the university, 4-H agents are able to

offer two incentives to faculty members: first, faculty members who volunteer are able to list their participation on NSF proposals as an in-kind contribution, and second, 4-H agents write letters to university leaders recognizing the faculty member's contribution to the program. To prepare faculty members to work with the target audience, agents leading the program offer training and support as volunteers plan their seminars, particularly in planning age-appropriate hands-on activities that demonstrate the application of a science field. One agent described the guidance offered to science experts, highlighting the goals in mind for youth: "I start them out with trying to have them understand the expectation of the audience, of who they are working with and why they're here, and what role I would like them to serve: […] Getting [participants] excited about science [and] feeling comfortable on campus."

Expose youth to new science fields and careers. The diversity of topics represented among the seminars and field trips introduces youth to the variety of ways they can engage in science. Youth, for example, can choose to attend sessions in biomedical engineering, ocean science, and food science. One faculty member explained, "The typical high school student has never heard the term 'food science.' They don't know anybody who works as a food scientist; they didn't even know it was a career option to be a food scientist." In addition to the seminars, the program leaders organize a field trip that showcases a branch of science outside of a laboratory setting. During the 2011 camp, youth visited researchers working in ocean science. The program leader explained, "My goal for [this trip] is to show them that there are a wide variety of ways that you can engage in science. It's connecting them to not only the university-level scientists but also seeing a whole group of federal-level scientists doing work at the ocean research center."

Connect youth to the science education pipeline. The camp experience emphasizes the science education pipeline by introducing youth to the college environment and highlighting connections between the academic study of science and careers. Seminar leaders received guidance from the program staff that suggested discussing how they became interested in their fields. In one observed session, a professor described how her interest in science began and the educational decisions she made in high school and college to reach her career goals. The camp also encourages youth to think about pursuing higher education: in addition to science-related activities, youth also attend a panel on applying to and paying for college.

Texas 4-H Technology Team
Texas

Program Context

Years in operation	7
Total youth served annually	About 15
Community served	Rural, suburban, and urban
Age range of participants	14-20
Target audience	Existing 4-H members with a well-established interest in technology
Meeting frequency	Two yearly in-person meetings; monthly virtual meetings
Curricular area(s)	Computer science, technology
Lead partners	Hewlett-Packard

The Texas 4-H Technology Team is a statewide leadership team for youth ages 14 and up in Texas. The team makes significant contributions to state and national 4-H events, during which youth provide technology-related training to youth and adults and present on relevant topics such as online safety. They also provide audio-visual technical expertise at events like the Texas 4-H Roundup, a large statewide event held each summer. Participants are recruited for their demonstrated interest in technology and participate in two in-person training sessions during the year. The team is advised by four adults – two 4-H extension agents and two industry professionals– and includes roughly 15 members each year.

Promising Practices and Lessons Learned

Design the application and acceptance process to build the desired participant profile. Recruitment efforts focus on older teens already enrolled in 4-H programming in Texas. Interested youth complete an extensive application consisting of three essays about their leadership skills, an assessment of their knowledge of technology, and a video component that requires applicants to produce a YouTube video in which they introduce themselves. Creativity is strongly encouraged in the video portion of the application. Youth are asked to include three letters of recommendation with their application and, though not required, some applicants submit a portfolio of work. Applicant selection for the upcoming program year is conducted primarily by the prior year's returning members; the team looks for established 4-H members who demonstrate maturity, creativity, and a strong interest in technology.

Use science content experts strategically. The team is led by four adults – two 4-H extension agents, a digital technology professor at a local community college, and a Hewlett-Packard employee. Youth formally and informally learned about the experts' work and careers, and the connection to Hewlett-Packard provided the team with valuable resources. In addition to adult content experts, long-time team members possessed great expertise and skill in certain

areas, such as digital photo manipulation. One college-aged member led two lengthy team trainings on Adobe Photoshop and digital moviemaking software. The youth and adult experts already on the team served as vital resources for inquiry, troubleshooting, and further content exploration.

Enable youth to drive content and activities. The Technology Team was designed to be a youth-adult partnership, rather than being strictly adult-driven. Adults serve as advisors and empower youth to make critical team decisions by assigning youth to various planning committees. The adults also aim to focus on technology that youth are interested in; the content focus of the team has gradually changed since the team's inception seven years ago. At each fall meeting, youth identify what trainings they want to do at the spring meeting; similarly, youth at the spring meeting decide what trainings will take place that fall. The team tries to find ways to align youth interests with various events; this year, several youth interested in robotics considered conducting a robotics demonstration at a large statewide summer event. Furthermore, participation on the team requires a significant amount of independent research and study, which is often transformed into a training or presentation.

Institutionalize of key program components. The Texas Technology Team publishes a handbook every program year that guides the team's activities, structure, and content; this handbook provides a common reference point for new and long-term members, youth and adult. Itself a collaborative effort that reflects team consensus, the handbook describes expectations for participation, processes for new member recruitment and vetting, key activities, task committees, agreed-upon topics for skill building, and the biographies of all youth and adult members. It has helped institutionalize some processes and roles in a program that is somewhat unstructured and without a standardized planned curriculum. The handbook contributes to program sustainability and aids others who may be interested in replicating the team's structure.