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Perceptions of Youth, Parents, Community Volunteers, Corporate Volunteers, and 4-H Professionals about the 4-H STEM Career Pathway Model

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Abstract

This study sought to understand the 4-H STEM Career Pathway Model program, a three-year initiative to expose youth to college readiness skills, career readiness skills, STEM skills, and careers associated with high-demand STEM jobs such as computer scientists and engineers. The qualitative study described here used document reviews, observations, focus groups, and individual interviews. The initiative was conducted in 13 states, and research participants were 4-H youth, parents, corporate volunteers, community volunteers, and Extension 4-H professionals from a subset of those states. Findings were described in four major themes: (a) 4-H STEM programs were perceived as successful and engaging, yet participants described the need for more advanced experiences for youth; (b) 4-H STEM programs required considerable investment in partnerships as well as professional and volunteer development; (c) increased numbers of girls and minority youth were engaged in 4-H STEM programming when local role models and local partnerships were leveraged, and (d) the 4-H STEM Career Pathway Model needs clear concepts and definitions to be a sustainable approach in the 4-H movement. The major recommendation is an enhanced 4-H STEM Career Pathway Model that delineates outcomes. Additional recommendations include the need to provide effective volunteer and professional development and the need for outreach to corporate volunteers.

Keywords: career pathways; 4-H; STEM; volunteerism

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Introduction/Literature Review

The 4-H Science: Building A 4-H Career Pathway Initiative was a collaboration between National 4-H Council and an aeronautical engineering corporation to help youth develop STEM and workforce skills necessary for success; to immerse youth in the field of STEM work; and to engage with the science and engineering career pathway. A key goal was to involve more girls and minority youth in STEM and STEM career fields to address disparities in the STEM workforce for women and minority groups (National Science Board, 2018). The initiative was conducted in 13 participating states, and the project planning, implementation, and evaluation was guided by a framework known as the 4-

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H STEM Career Pathway Model. Ultimately, the initiative aimed to contribute to a robust pipeline for science professions in high-demand careers such as computer scientists and engineers.

Although the literature on nonformal (also known as out-of-school time) STEM education lacks strength (Nippolt, 2014), available findings indicate that these experiences are valuable for youth with nonformal STEM participation in middle and high school related to pursuing advanced STEM education (Gottfried & Williams, 2013). Furthermore, research and evaluative studies of 4-H STEM programs have shown that the programs help youth gain knowledge, seek new aspirations, develop life skills, and form positive attitudes about science. Various 4-H science programs have been successful at teaching diverse STEM subjects as measured by self-report questionnaires including robotics (Barker et al., 2008) biotechnology (Ripberger & Blalock, 2013), and aquaculture (Horton & House, 2015). 4-H participation is associated positively with academic success related to higher math and science standardized test scores (Flores-Lagunes & Timko, 2014) and taking more advanced science courses in school (Heck et al., 2012; Lerner & Lerner, 2013; Rice et al., 2016). It is possible that these positive school outcomes are related to the effort of 4-H professionals to align STEM programming with Common Core and/or Next Generation Science Standards (Noble, 2018). Furthermore, 4-H STEM programs are associated with increased interest in obtaining STEM jobs (Salle et al., 2019). A survey of more than 400 youth participating in 4-H STEM programs in eight states found that 4-H youth self-reported that their attitudes about future science-related careers were greater than the National Assessment of Educational Progress benchmarks (Mielke & Butler, 2013).

Furthermore, 4-H STEM programs have been linked with increased positive attitudes about STEM courses and careers. This includes increased perception of science self-efficacy (Salle et al., 2019). In a study of youth in five rural 4-H robotics camps, researchers found that youth increased skills in decision-making, use of limited resources, and teamwork (Sage et al., 2018). Salle et al. (2019) found that Latino 4-H reported increased science self-efficacy after participating in an animal science-based biotechnology and digital media workshop.

In order to engage youth throughout the country, 4-H STEM and other 4-H programs are implemented with and through volunteer adult leaders who are managed by Extension 4-H professionals. Volunteers face a variety of complexities in nonformal educational settings such as youth who attend meetings sporadically and youth that represent a range of ages and stages of development (Worker & Ching, 2016). In addition, these volunteers frequently do not have the necessary competence and/or confidence to deliver STEM education. A nationwide study of Extension 4-H professionals found that slightly more than one-half identified a major challenge was finding qualified science content experts/volunteers to lead 4-H STEM programs (Turnbull, 2013).

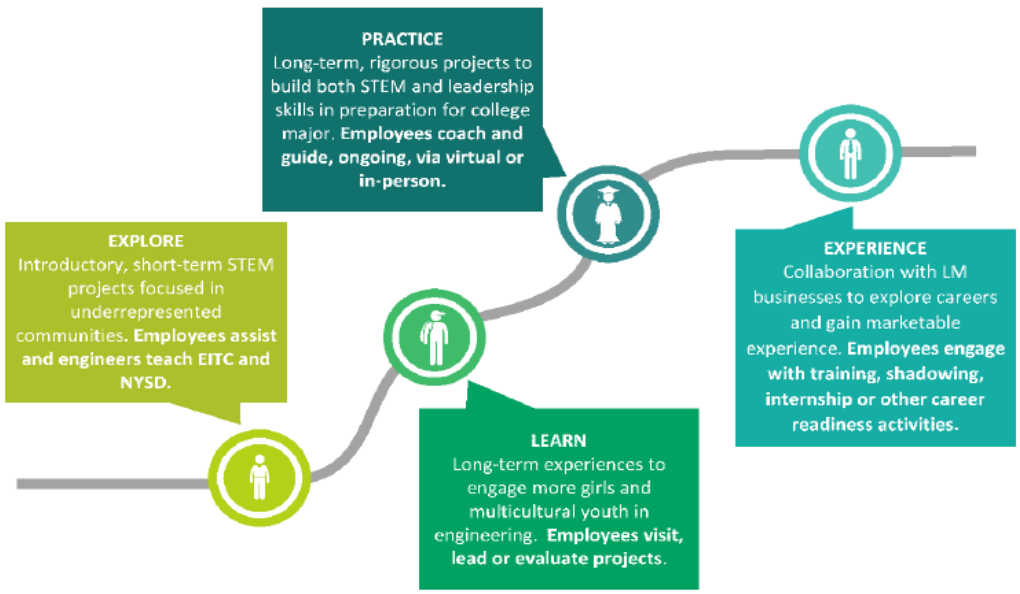
Emerging research on nonformal STEM education suggests that having effective role models for youth produces substantial outcomes. In surveys and interviews with 167 alumni of a nonformal STEM program, women reported much greater increases in STEM interest than men because of the program. Interviews indicated that the outcomes for women were driven by relationships among female participants and female leaders (Price, Kares, Segovia, & Brittian Loyd, 2019). One avenue for nonformal STEM organizations in identifying and utilizing effective role models is corporate volunteerism. Corporate volunteerism may have an important role in nonformal STEM education. For example, UL employees have served in various volunteer roles for nearly 50 *FIRST* robotics events which expose youth to STEM careers in nonformal, interactive learning environments and competitions (Veleva et al., 2012).

Theoretical Framework

The 4-H STEM Career Pathway Model (Figure 1) provided an overall outline of 4-H youth activities and corporate volunteer contributions (from an aeronautical engineering corporation). The model was proposed by National 4-H Council and funded by the same aeronautical engineering corporation. The proposed model was informed by two studies and the National 4-H Science Logic Model.

Figure 1

4-H STEM Career Pathway Model at Project Inception



Nippolt (2012) studied skills and confidence of lead trainers, adult facilitators, and overall program efficacy of a 4-H STEM program in five states. As opposed to a strict program checklist or a strict set of lesson plans, the approach was to examine the performance of the overall application model. An application model is concerned with the program concepts and the application to local contexts (Ottoson, 1997). The application model was operationalized in this initiative through the 4-H STEM Career Pathway Model.

Riley and Butler (2012) conducted a national review of eight promising 4-H science programs. They recommended three practices which were performance goals for of the 4-H Science: Building A 4-H Career Pathway Initiative state grantees. The first goal was that science experts ought to lead local 4-H STEM programs, and the second goal was that under-represented youth ought to be recruited through schools and urban communities. The final goal was to expose youth to science careers. The corporation was to provide the science experts to serve as corporate volunteers in conducting the local 4-H STEM programs.

The National 4-H Science Logic Model includes science, technology, engineering, and mathematics, and it describes programming and partnerships that will produce a diverse pool of youth pursuing education and careers in science related fields (4-H.org, 2010).

The 4-H STEM Career Pathway Model was expressed by National 4-H Council (2015) with four phases. The first phase, explore, involves youth in introductory, short-term STEM projects focused in underrepresented communities. This phase is characterized by engineers (corporate volunteers) teaching youth in two STEM programs: Engineers in the Classroom, a corporation effort to reach youth with STEM education, and National Youth Science Day, a 4-H activity to enrich science literacy among youth. The next phase is the learn phase which involves long-term experiences to engage more girls and under-represented youth in engineering. In this phase, corporate volunteers visit, lead, or evaluate 4-H STEM projects. The third phase, practice, is composed of long-term, rigorous projects to build both STEM and leadership skills in preparation for a college STEM major. In this phase, corporate volunteers provide ongoing coaching and guidance to youth either virtually or in-person. The final phase is the experience phase in which youth collaborate with corporate volunteers to understand careers and gain marketable experience. Employees engage with training, shadowing, internship or other career readiness activities for youth.

Purpose/Objectives

The overall purpose of this study was to understand perspectives from youth, parents, community volunteers, corporate volunteers, and 4-H professionals regarding the 4-H STEM Career Pathway Model. The study supports National Research Priority six (Vibrant, Resilient Communities) which includes the needs to understand how Extension programs impact local communities and to engage volunteers in program delivery (Graham et al., 2016). The objectives were to understand perceptions of 4-H youth, parents, community volunteers, corporate volunteers, and 4-H professionals regarding:

1. Successes and challenges for the 4-H STEM Career Pathway Model in producing local impacts.
2. Ways to make the 4-H STEM Career Pathway Model a sustainable, quality approach for effectively engaging youth, especially girls and minorities, and volunteers.

Methods

The research reported here was one component of an intensive, three-year process evaluation to assess 4-H STEM Career Pathway Model projects implemented by state 4-H programs in 13 states (herein referred to as state grantees). Process evaluations are conducted to document the extent to which program activities are implemented according to plan (CDC, 2017) with a focus on inputs/resources, activities, participation, and reactions (Fitzpatrick et al., 2004; Radhakrishna & Bowen, 2010). Consistent with process evaluation work, the research reported here focused both on outcomes related to the effects of direct programming activities on involved youth as well as successes, best practices, and recommendations for future programming. Other aspects of this process examined volunteer training needs for successful 4-H STEM programs (Franck & Donaldson, 2020) and 4-H STEM program quality (Donaldson & Franck, in press). This research was approved by the University of Tennessee Institutional Review Board (UTK-IRB-15-02714-XP).

Participants

Participants were 4-H youth and parents, Extension 4-H professionals, and volunteers participating in 4-H STEM program funded by the 4-H Science: Building a 4-H Career Pathway Initiative. The actual 4-H programs varied by location and included after-school 4-H STEM programs, community 4-H robotics clubs, state 4-H conferences, and in-school 4-H enrichment programs focused on gardening. All participants signed consent forms for both the observations and focus groups. Researchers obtained both parental consent and youth assent for youth participants.

Procedures

Mixed methods research is characterized by the quantitative and qualitative strands with results and conclusions based on the combined cogency of the data (Creswell, 2015; Creswell & Plano Clark, 2018). This study used Creswell and Plano Clark's (2018) explanatory sequential mixed methods research design: (step 1) *design and implement the quantitative strand*; (step 2) *use strategies to connect from the quantitative strand*; (step 3) *design and implement the qualitative strand*; and (step 4) *interpret the connected results*.

Design and Implement the Quantitative Strand (Step 1)

In step one, we collected and aggregated monthly activity reports via the Qualtrics Research Suite (2019) from all 13 state grantees. The monthly activity reports included information about: (a)

Youth participants (gender, race, ethnicity, total number of youth contacted, and the stage of 4-H STEM Career Pathway Model in which the youth participated); (b) 4-H professionals (number involved in the project and the hours they contributed); (c) Community volunteers (number involved in the project and the hours they contributed); (d) Corporate volunteers (number involved in the project and the hours they contributed); and (e) Curriculum used, approaches, and innovations in reaching youth.

Use Strategies to Connect from the Quantitative Strand (Step 2)

The funding agency had set benchmarks for state grantees that included serving up to 60% girls and minorities. We used this quantitative data to select the states to visit. States were organized into two cohorts. Cohort 1 were the three states implementing all four phases of the 4-H STEM Career Pathway Model, and Cohort 2 were those states only implementing the explore phase of the 4-H STEM Career Pathway Model. We selected all three of the Cohort 1 states (States 1, 2 and 3) because these states could provide the most depth and breadth regarding experience with the model. We also selected four of the 10 states that had exceeded benchmarks for total youth reached, had the highest percentages of girls reached, had the highest percentages of minority youth reached, and/or had the most developed partnerships with corporate volunteers (States 4, 5, 6, and 7). Of these four states, three were included in this research project (States 4, 6, and 7) as various natural disasters prevented scheduling a visit to State 5.

Design and Implement the Qualitative Strand (Step 3)

Within each of the selected states, we traveled to sites selected by the state grantee and conducted individual interviews and focus groups with 4-H youth, parents, community volunteers, corporate volunteers, and 4-H professionals. An example question for Extension professionals, 4-H community volunteers, and 4-H corporate volunteers was "What recommendations do you have to improve this project/process?" and an example question for 4-H youth and parents was "Would you recommend this program to other youth and families? Why/why not?"

Focus group interviews were conducted with 4-H youth and parents in the same focus groups, and all other participants were in groups for their distinct audience (community volunteers, corporate volunteers, and 4-H professionals were interviewed in distinct groups). We interviewed 29 participants in individual interviews and 126 participants in group interviews (Table 1).

Table 1

Participants in Focus Groups and Individual Interviews

	4-H Youth	4-H Parents	Community Volunteers	Corporate Volunteers	4-H Professionals
Individual Interviews	9	7	9	0	4
Focus Group Participants	40	19	5	7	55
Number of Focus Groups	4	3	1	2	7

Note. The focus group interviews ranged in size from 2 to 26 participants with a mean of 7.41 participants.

The format of the 4-H STEM educational program dictated how individual interviews and focus groups were conducted. For example, at a community 4-H STEM club, parents and youth participated in one large focus group as most families had walked to the meeting. Conversely, in a community 4-H robotics club, parents were interviewed individually because they arrived at different times to pick-up their children after the club meeting.

We also observed actual 4-H STEM programs being conducted as part of this initiative, and individual interviews and focus groups typically were held at the same location and time as the 4-H STEM programs. Site visit observations were designed and conducted using Patton's standards for evaluative site visits (2015). All observational data was collected via the Out of School Time (OST) Observation Instrument with STEM Plug-In which helped synthesize observations to understand the extent to which 4-H STEM activities promoted skill-building, active learning, relationships among youth and between youth and staff, and engagement in specific learning and/or developmental goals (Pechman et al., 2008).

Interpret the Connected Results (Step 4)

The individual interviews and focus groups were recorded via digital audio recorders and transcribed. We read and re-read the transcripts, and we used an open-coding (inductive) approach (Marshall & Rossman, 2006; Saldaña, 2014). The open coding approach was characterized by both in vivo coding which is to code using the exact words of the participant (Strauss, 1987) and descriptive coding which is to code using nouns to describe the data (Saldaña, 2014). The codes from each individual interview and focus group were then aggregated across all individual interviews and focus groups, and key themes that emerged were noted. As an explanatory sequential mixed methods research design, the quantitative and qualitative data sets were separately obtained and analyzed, the results of each were merged and compared, and finally, the combined results were interpreted (Creswell & Plano Clark, 2018). f

Trustworthiness, Credibility, and Transferability

We collected all of the data ourselves, and we employed peer debriefing, thick, rich descriptions, and member checking to establish trustworthiness (Teddlie & Tashakkori, 2009). We attended the first observation together, made separate use of the OST Observation Instrument, and compared our results. Our observation results were identical, underscoring the strong reliability of the OST Observation Instrument. This instrument has documented inter-rater reliability, internal consistency, construct validity, concurrent validity, and validity of scale structure (Pechman, at al., 2008). Furthermore, the OST Observation Instrument promotes thick, rich descriptions by prompting observers to synthesize the youth program in regards to activities, skill-building, active learning, relationships, and task orientations. Peer debriefing was employed by engaging with the National 4-H STEM Career Pathway Working Group, a committee of seven professionals and researchers. Of the seven working group members, five were directly engaged in the 4-H Science: Building A 4-H Career Pathway Initiative. We used member checking by presenting the study methods, findings, and conclusions to all of the state grantees through two webinars (Teddlie & Tashakkori, 2009).

Regarding credibility and transferability, we observed diverse 4-H programs and interviewed 4-H youth and parents, Extension 4-H professionals, and volunteers in six different states. We triangulated monthly activity reports; individual interview and focus group data; and observational data to understand the total 4-H STEM Career Pathway Model effort (Creswell, 2015; Creswell & Plano Clark, 2007; Teddlie & Tashakkori, 2009).

Findings

From our analysis, four major themes emerged: (a) 4-H STEM programs were perceived as successful and engaging, but needed advanced experiences for youth; (b) 4-H STEM programs require considerable investment of resources that include partnerships as well as professional and volunteer development; (c) increased numbers of girls and minority youth were engaged in programming when local role models and local partnerships were leveraged, and (d) the 4-H STEM Career Pathway Model needs clear concepts and definitions to be a sustainable approach in the 4-H movement.

Theme 1: 4-H STEM Career Pathway Model Activities Were Perceived as Successful and Engaging, but Needed Advanced Experiences for Youth

The 4-H STEM activities provided as part of this grant received positive comments from youth, parents, community volunteers, corporate volunteers, and 4-H professionals. These activities were engaging, successful, and provided hands-on learning that complemented and reinforced knowledge and content from school science classes. Observed clubs and events demonstrated hands-on activities that were youth-driven with guidance from professionals and volunteers. Two key components contributed to the success of 4-H STEM activities: (a) youth engagement and enthusiasm for the activities, and (b) support and guidance for youth provided by 4-H professionals and volunteers throughout the activities.

Youth Engagement and Enthusiasm for the Activities

Comments from youth, parents and volunteers and our observations indicated that youth were excited about these activities. Several parents commented that this was the first out-of-school activity that their children wanted to attend and did not want to miss. Parents and youth also appreciated the hands-on aspect of activities. Parents identified the way 4-H STEM activities included all youth who wanted to participate—not just the top students. Parents also appreciated how 4-H STEM was focused more on cooperation and helping others rather than winning competitions, as one parent explained: "The kids get to do things on their own. It's not adult-driven. It's child-driven. The children get to explore different things and figure out what works and figure out what doesn't work. They're working out their problems on their own" (State 2 Parent).

Both parents and youth discussed how staff provided support and guidance. Youth reported that this support and guidance was in contrast to large school science classes where one-on-one instruction is limited. Typical comments included the sentiment expressed by one 4-H youth: "In school, since there's more students, you don't really get one-on-one help and then you don't really understand what you're doing. When you're here, since we have mentors, we get more help" (State 1 Youth).

Lack of Advanced STEM Activities at the Practice and Experience Phases

Our interviews revealed that Extension 4-H professionals were not comfortable and had limited experience organizing advanced STEM activities. Specifically, Extension 4-H professionals were not comfortable organizing aeronautical engineering corporation employees for coaching, job shadowing, internships, and other career development activities. Aeronautical engineering corporation employees and 4-H community volunteers echoed the need to provide more advanced experiences for youth at the practice and experience phases. In our interviews, this arose from the question, "What would make this program better?" One corporate volunteer suggested that 4-H robotics programs should include "more…math, physics, science behind what's physically going on…" (State 3 Corporate Volunteer). Extension 4-H professionals explained that the corporate link needed to be strengthened and institutionalized so that 4-H youth had opportunities for career experience, including job shadowing and internships. A representative comment was:

> "I think it would be awesome if 4-H could leverage the relationship that they have with people like [aeronautical engineering corporation], so that in addition to doing this programming that we're providing more concrete opportunities to go beyond. Something that motivates a youth from sixth grade through high school to stick with it. Like there's going to be x number of internship positions or college [or] university grants or jobs. We're saving x number of jobs to hire from youth that went through this program" (State 1 Extension 4-H Professional).

Theme 2: For Effective Nonformal STEM Learning among Youth, 4-H Must Continue to Invest in Partnerships as well as Professional and Volunteer Development

The initiative was powered by significant human capital from Extension 4-H professionals, corporate volunteers, and 4-H community volunteers. A project goal was to engage 500 aeronautical engineering corporation employees and 1,000 4-H community volunteers. The project exceeded these benchmarks with 521 corporate volunteers and 3,679 4-H community volunteers engaged. The typical Extension 4-H professional managed 214 4-H community volunteers and engaged 30 corporate volunteers who collectively reached 5,212 youth per year.

Identifying Win-Win Situations

Corporate volunteers and Extension 4-H professionals reported that through their interactions, they had learned to identify win-win situations to facilitate working together. One 4-H professional described their journey: "They [aeronautical engineering corporation] didn't know us. We didn't know them. . . I don't think that they probably felt comfortable going to a foreign environment to go volunteer for an organization that I don't really know. . . So I think it took about a year to try to finally get our foot solidly in the door before we really established that relationship" (State 3 Extension 4-H Professional).

Limited STEM Knowledge for 4-H Professionals and Community Volunteers

Several 4-H professionals identified their limited knowledge and skills related to STEM subject matter: "I need someone to take time and go slowly with me on coding robots" (State 2 Extension 4-H Professional). 4-H professionals also felt that many potential community volunteers lacked STEM skills and abilities, and one 4-H professional described that "traditional 4-H volunteers are still scared to death of science. . . they see science as something in a lab" (State 7 Extension 4-H professional).

Youth talked about the limitations of working with Extension professionals and club volunteers who did not have science backgrounds. This finding is a clear indication of the important need filled by corporate volunteers who provide the content expertise needed for deeper STEM learning. The 4-H professionals expressed the need for more corporate volunteer involvement in their local programming which would increase STEM knowledge among youth, volunteers, professionals, and communities. One suggestion from corporate volunteers and 4-H professionals for overcoming limited science skills was having prepackaged curricula that were readily accessible for 4-H professionals and volunteers.

Limited Youth Development Knowledge for Volunteers

Interviews identified the need to improve youth development skills, particularly among corporate volunteers. One employee described their experience this way:

> "I remember the first time I went into [agency]. I'd put a PowerPoint up and lost half of them about slide two or something. So I had the best intentions, but you have to know how to work with every different audience, and I think that's training is a very event-specific thing because it could be a different audience one time versus the next time." (State 1 Corporate Volunteer)

Theme 3: The 4-H STEM Career Pathway Model Involved Girls and Minority Youth When Local Role Models and Local Partnerships were Leveraged by Extension 4-H Professionals

A project goal was to reach 30,000 youth in STEM and career development programs with up to 60% representing girls and 50% representing racial/ethnic minority groups. Of the 89,291 youth reached in this initiative, 48% were girls and 53% represented racial/ethnic minority groups. In most communities, purposeful outreach proved essential, but in some communities, 4-H professionals reported that they did not employ any special outreach or approach to reach minority youth and girls: "I don't think we've done specific recruitment for this project to increase female participation because they're already there participating" (State 2 Extension 4-H Professional). In communities that employed purposeful outreach, the two predominant and successful strategies were providing adult role models for youth and developing local partnerships.

Providing Role Models

One successful practice was to engage STEM professionals and/or college students who could serve as role models for girls and minority youth. "You see a lot more interest…..before they did not see a lot of women they could think of in [STEM] career paths. Now, a lot more standout. Here at [4-H] Teen Conference, you've got people, a lot of female teaching science, engineering, and technology, and seeing that visual, realizing 'OK I can do that' has been helpful" (State 7 Extension 4-H Professional).

A 4-H professional noted that her own involvement with the project was positive for girls and minorities because she represented, "another black woman that's into science" (State 3 Extension 4-H Professional) for the youth. Several 4-H professionals and corporate volunteers also felt that it was important that volunteers be young so that 4-H youth were "building relationships with college and college-bound students" (State 1 Corporate Volunteer).

Developing Local Partnerships

In addition to the key partnership with corporate volunteers, local partnerships were formed to engage girls and minority youth. Examples include working with a women's basketball team to sponsor a 4-H STEM Awareness Night and recruiting volunteers from professional scientific organizations for minorities and women. The most notable professional association for volunteer recruitment were local chapters of the National Society for Black Engineers. 4-H curriculum, especially 4-H National Youth Science Day curriculum kits, were lauded by local partners. One illustration was the Incredible Wearables used in 2017. In this curriculum, youth built simple fitness trackers to measure activity and heart rate. A high school teacher who incorporated 4-H STEM activities into high school technology classes and served as the 4-H volunteer leader stated:

> "The robotics was really one of the best because I have kids that have not done programming before. That's something that we have not offered at our school…..that's going to be used from now on. Coding and programming, we need to strengthen here at [school]. We need to strengthen the coding. The electronics part is great because all kids need to know some basics in electronics and electricity. And working with the Incredible Wearables was really good because [the students] didn't know you can just take some simple things and put it together, you know, and have that happen" (State 4 Community Volunteer).

Theme 4: The 4-H STEM Career Pathway Model Shows Promise for Connecting 4-H Youth to Careers, but Lacks Clear Concepts and Definitions

Momentum for Connecting 4-H STEM to Careers

Respondents identified the importance of connecting 4-H STEM activities to advanced educational opportunities and future careers. 4-H youth recommended 4-H STEM to others because "in the future we can get a job in it" (State 1 4-H Youth). Parents view 4-H as providing youth the opportunity to pursue their passions and interests while connecting youth interests to higher education (including scholarships) and careers. The 4-H STEM Career Pathway Model inspired some Extension 4-H professionals to want to incorporate career development in all 4-H projects and activities. However, observational data indicated a lack of connection between 4-H STEM activities and real-world applications and to educational pathways and careers.

Definition of Concepts and Expectations

4-H professionals described the need for a 4-H STEM Career Pathway Model with more details and that "definitions need to be clearer" (State 3 Extension 4-H Professional). They described how 4-H professionals spent considerable time discussing the similarities and difference among the four different phases of the pathway. As one 4-H professional noted, "I feel like the theory and the potential of the pathway is not articulated well enough" (State 1 Extension 4-H Professional).

Discussion

When programs are complex, needs are great, and solutions are untested, a process evaluation is an important first step to evaluate activities, audiences, and best practices (Fitzpatrick et al., 2004). This study was part of an overall process evaluation, and this study has some important limitations and contextual factors. As previously discussed, all of the measures, including the OST Observation Instrument, were available to state grantees in advance. We do not know the extent to which having access to the observation form in advance may have influenced answers to focus group questions. The funding agency asked for observations and interviews only with those states that were meeting benchmarks. This provided an in-depth analysis of states that were performing, but no information about the barriers faced by under-performing states. Engineering was the predominate focus of the programs observed which may have been due to the donor and corporate volunteers who represented an aeronautical engineering firm. Extension 4-H professionals and corporate volunteers discussed the need for more advanced STEM programming, especially in deeper STEM learning, job shadowing, and internships. The observations echoed this need. Yet, we noted a triangulation of data around the need for more program development. During the course of the three-year program, several state grantees expressed the need for stronger curricula, specifically in career development for youth and STEM skills for Extension 4-H professionals. By the third year of the grant, all of the state grantees had access to the same tools, Build Your Career, Click2Science, and Couragion. However, these tools were not discussed in focus groups, and the researchers saw none of these curricula during program observations.

Additional applied research is paramount to understanding how 4-H, communities, and organizations work together to prepare youth to fully succeed in life and career. Future research is a critical contribution to building stronger career pathways for youth and ultimately, a robust pipeline for STEM professions.

Conclusions/Recommendations/Implications

This study revealed some common accomplishments and challenges across states. Youth received substantial support and guidance from a cadre of Extension 4-H professionals, 4-H community volunteers, and corporate volunteers. This resulted in youth who were engaged and enthusiastic about STEM including girls and underserved minority youth especially in 4-H STEM programs that made an effort to identify and engage role models with STEM expertise to serve as volunteers. Similar to Price et al. (2019), we found that relationships between girls and women role models are key to girls' STEM interest and success. However, in some communities, no special outreach was needed as the 4-H program had strong involvement of girls and minorities before the initiative.

Many Extension 4-H professionals felt that their STEM educational background is inadequate for today's youth. Professional development is recommended to "level-up" the STEM skills of Extension 4-H professionals (Worker et al., 2017). In addition to STEM skills, Extension 4-H professionals report being ill-prepared to implement more advanced career development experiences for youth such as job shadowing and internships. Therefore, the Cooperative Extension System and National 4-H Council should explore ways to promote greater Extension professional engagement in career development activities (specifically the practice and experience phases). Virtual career development could mediate difficulties related to travel, time, and work demands. Extension 4-H professionals also reported the need to improve the volunteer training opportunities to focus on youth development and pedagogy. Extension 4-H professionals and corporate volunteers discussed the importance of having prepackaged STEM curriculum to serve youth in a more robust way.

Findings identified the need to further develop the 4-H STEM Career Pathway Model and align youth development and 4-H STEM curriculum. 4-H professionals consistently expressed difficulty understanding definitions, concepts, and different phases of the 4-H STEM Career Pathway Model. Yet, they also expressed that the initiative had developed their awareness of the need to integrate career development with all 4-H projects.

To scale-up 4-H STEM programming and reach more girls and minority youth, we proposed an enhanced 4-H STEM Career Pathway Model. This proposed 4-H STEM Career Pathway Model was validated by the National 4-H STEM Career Pathway Working Group, a committee of seven professionals and researchers representing four land grant universities and National 4-H Council. Of the seven working group members, five had been involved in this initiative. These different perspectives provided valuable counsel on how to enhance the existing 4-H STEM Career Pathway so that it would positively impact the entire 4-H movement. All of the working group members had either written 4-H career development curriculum or were practitioners with exceptional 4-H career development programming and local impacts. The working group examined our findings and our proposed 4-H STEM Career Pathway Model. Each member was tasked with applying the revised 4-H STEM Career Pathway Model to a local STEM program in their state which had not been part of the current initiative. This was done to understand if the revised model was specific enough to strengthen 4-H STEM programming, but conceptually broad enough to be useful across varied 4-H delivery methods and audiences. This group met one time face-to-face (for one day) and via video conference three times to discuss ways to improve the model given the results of this study and the group's local experiences with the revised model. The Enhanced 4-H STEM Career Pathway Model (Figure 2) reflects the study results and our discussions with the working group.

Figure 2

Enhanced 4-H STEM Career Pathway Model

4-H STEM Career Pathway for Youth Success

Growing a Generation Prepared to Succeed in Life & Career

	Explore	**Learn**	**Practice**	**Career Experience**
Youth Grade in School	All Grades		8-12th Grades	
Milestones	Youth explore concepts to develop awareness in STEM, college and career readiness for 21st Century success.	Youth learn skills and abilities in STEM, college and career readiness for 21st Century success.	Youth practice and apply real world skills and abilities in STEM, college and career readiness for 21st Century success.	Youth gain career experience in STEM that informs their college and career decisions for 21st Century success.
Outcomes	Youth will: • Express interest and be engaged in science related activities. • Express positive attitudes about science.	Youth will: • Demonstrate a capacity for science process skills. • See science in their futures and recognize the relevance of science. • Express positive attitudes about engineering. • Demonstrate a capacity for engineering skills.	Youth will: • Draw connections to real-world concepts and situations. [a] • Discuss STEM careers and their educational pathways. [a] • Apply science skills to issues in their community. • Make contributions to their peers, families, and communities.	Youth will: • Demonstrate professional communication appropriate to the academic and workplace context. • Demonstrate the social, emotional, character, and leadership skills necessary for academic or workplace success. • Make informed decisions about college aspirations that are personally meaningful. • Make informed decisions about career aspirations that are personally meaningful.

[a] These outcomes are from: Pechman, E.M., Mielke, M.B., Russell, C.A., White, R.N., Cooc, N. (2008). *Out-of-School time (OST) observation instrument: Report of the Validation Study*. Washington, DC: Policy Studies Associates. All other outcomes are from National 4-H Council Common Measures (2017)

Because of the findings that indicate that this was a successful initiative, it is recommended that programming continue and expand throughout the country. Every youth, parent, corporate volunteer, community volunteer, and Extension 4-H professional interviewed recommended the initiative for broader implementation. We recommend that the Enhanced 4-H STEM Career Pathway Model be used for program development and evaluation, including curriculum development. Programs using the enhanced model need to undergo rigorous research to further understand how the model can contribute to better 4-H STEM programs that perform well for all youth. Additionally, research is needed to understand what current curricula, if any, supports the enhanced model

When college lecturers were taught how to deliver STEM content in nonformal ways, lecturers improved their attitudes, leadership, social skills, and class creativity (Alonso Terrazas-Martin, 2017). Research is needed to understand if STEM education has these or other benefits for Extension 4-H professionals.

Youth and parents discussed the importance of one-on-one instruction and mentoring. This finding underscores the important role of 4-H in STEM learning and achievement. Interestingly, this finding echoes Bloom's 1984 groundbreaking research which emphasized the role of individualized instruction, mastery learning, and the need to explore how group instruction could be as effective as individual instruction. Additional research should explore the effectiveness of 4-H one-on-one instructional settings and curricula. In addition, future research needs to identify how to effectively evaluate programs in nonformal environments where learning is highly social and interactive (Allen & Peterman, 2019).

It is recommended that the Cooperative Extension System develop a long-range plan for involvement of corporate volunteers. For STEM nonformal learning, corporate volunteers are particularly important as Extension 4-H agents perceived that both themselves and community 4-H volunteers lacked the STEM expertise needed to help today's youth succeed. Corporate volunteerism shows great promise (Veleva et al., 2012), and research should explore how 4-H STEM programs reflect both work design and volunteerism theories (Grant, 2012).

Of the 10 states implementing only the explore phases of the 4-H STEM Career Pathway Model, none met all three of the targeted benchmarks across the three years: total youth participation, female youth participation, minority youth participation Site visits were conducted in states with the highest overall participation numbers. The state grantees that failed to meet any benchmarks (for overall youth served, girls served, and minorities served) are not well understood. Yet, it is interesting that money is not the most critical limitation as all of the state grantees received the same amount of funding to implement the program. Future research is needed to understand the barriers and contextual factors this group of under-performing states faced. As an illustration, the explore phases emphasizes introductory, short-term activities. It is possible that long-term, in-depth 4-H programming, such as clubs, are encouraged in some counties and states which leaves little time for short-term activities that target new audiences. Information about barriers and contextual factors is critical to have in planning for future use of the 4-H STEM Career Pathway Model and making future investments in STEM programming so that barriers can be understood and mitigated.

References

4-H.org. (2010). National 4-H science logic model. https://4-h.org/wp-content/uploads/2016/02/4-H-Science-Logic-Model.pdf

Allen, S., & Peterman, K. (2019). Evaluating informal STEM education: Issues and challenges in context. In A.C. Fu, A. Kannan, & R.J. Shavelson (Eds.), *Evaluation in Informal Science, Technology, Engineering, and Mathematics Education. New Directions for Evaluation, 161*, 17-33. https://doi.org/10.1002/ev.20354

Alonso Terrazas-Marín, R. (2018). Developing non-formal education competences as a complement of formal education for STEM lecturers, *Journal of Education for Teaching, 44:1*, 118-123. https://doi.org/10.1080/02607476.2018.1422613

Barker, B.S., Nugent, G., Grandgenett, N., & Hampton, A. (2008). Examining 4-H robotics in the learning of science, engineering and technology topics and related student attitudes. *Journal of Youth Development 2* (3). https://doi.org/10.5195/jyd.2008.329

Bloom, B.S. (1984). The two-sigma problem: The search for methods of group instruction as effective as one-on-one teaching. *Educational Researcher, 13* (6), 4-16. https://doi.org/10.2307/1175554

Centers for Disease Control and Prevention. (2017). Types of evaluation. https://www.cdc.gov/std/Program/pupestd/Types%20of%20Evaluation.pdf

Creswell, J. (2015). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson.

Creswell, J.W. & Plano Clark, V.L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.

Creswell, J., & Plano Clark, V. (2007). *Designing and conducting mixed methods research*. Sage.

Donaldson, J.L., & Franck, K.L. (2020). A mixed methods evaluation to measure 4-H STEM program quality. *Journal of Youth Development, 15*(5), 203-319. http://dx.doi.org/10.5195/jyd.2020.835

Fitzpatrick, J.L., Sanders, J.R., & Worthen, B.R. (2004). *Program evaluation: Alternative approaches and practical guidelines* (3rd ed.). Pearson.

Flores-Lagunes, A., & Timko, T. (2014). Does participation in 4-H improve schooling outcomes? Evidence from Florida. *American Journal of Agricultural Economics, 97*(2), 414-434. https://doi.org/10.1093/ajae/aau060

Franck, K.L., & Donaldson, J.L. (2020). Volunteer training needs for successful 4-H STEM programs. *Journal of Youth Development, 15*(4), 97-109. https://doi.org/10.5195/jyd.2020.856

Gottfried, M., & Williams, D. (2013). STEM club participation and STEM schooling outcomes. *Education Policy Analysis Archives, 21(*79), https://doi.org/10.14507/epaa.v21n79.2013

Graham, D.L., Arnold, S., & Jayaratne, K.S.U. (2016). *American Association for Agricultural Education national research agenda: 2016-2020*. Gainesville, FL: Department of Agricultural Education and Communication.

Grant, A.M. (2012). Giving time, time after time: Work design and sustained employee participation in corporate volunteering. *Academy of Management Review, 37*(4), 589-615. https://doi.org/10.5465/amr.2010.0280

Greene, J. (2015). Preserving distinctions within the multimethod and mixed methods research merger. In S. Hesse-Biber & R.B. Johnson (Eds.), *The Oxford handbook of multimethod and mixed methods research inquiry* (pp.606-615). Oxford: Oxford University Press.

Heck, K. E., Carlos, R. M., Barnett, C., & Smith, M. H. (2012). 4-H participation and science interest in youth. *Journal of Extension, 50*(2). https://www.joe.org/joe/2012april/a5.php

Horton, R.L., & House, P.L. (2015). Fish farm challenge provides STEM design experience for youth. *Journal of Extension, 53*(4). https://www.joe.org/joe/2015august/iw6.php

Lerner, R. M., & Lerner, J. V. (2013). T*he positive development of youth: Comprehensive findings from the 4-H Study of Positive Youth Development*. Tufts University Institute for Applied Research in Youth Development. https://4-h.org/wp-content/uploads/2016/02/4-H-Study-of-Positive-Youth-Development-Full-Report.pdf

Marshall, C. & Rossman G.B. (2006). *Designing qualitative research* (4th ed.). Sage.

Mielke, M., & Butler, A. (2013). *4-H science Initiative: Youth engagement, attitudes, and knowledge study.* Policy Studies Associates, Inc. https://files.eric.ed.gov/fulltext/ED591155.pdf

National 4-H Council. (2015, April 26). Filling the STEM pipeline: National 4-H Council and Lockheed Martin to prepare more diverse youth for STEM careers. https://4-h.org/media/filling-the-stem-pipeline-national-4-h-council-and-lockheed-martin-to-prepare-more-diverse-youth-for-stem-careers/

National Science Board. (2018). *Science and engineering indicators 2018*. NSB-2018-1. Alexandria, VA: National Science Foundation. https://www.nsf.gov/statistics/indicators/

Nippolt, P.L. (2012). 4-H Science: evaluating across sites to critically examine training of adult facilitators. *Journal of Youth Development, 7*(4). https://doi.org/10.5195/jyd.2012.114

Noble, R.E. (2018). *Kentucky 4-H minimizes barriers to STEM education* [Doctoral dissertation, Eastern Kentucky University]. Online Theses and Dissertations. https://encompass.eku.edu/etd/548

Ottoson, J.M. (1997). Beyond transfer of training: Using multiple lenses to assess community education programs. In A.D. Rose & M.A. Leahy (Eds.), *New directions for adult and continuing education* (pp.87 – 96). Sage.

Patton, M.Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Sage.

Pechman, E.M., Mielke, M.B., Russell, C.A., White, R.N., & Cooc, N. (2008). *Out-of-School time (OST) observation instrument: Report of the validation study*. Policy Studies Associates, Inc.

Price, C.A., Kares, F., Segovia, G., & Brittian Loyd, A. (2019) Staff matter: Gender differences in science, technology, engineering or math (STEM) career interest development in adolescent youth, *Applied Developmental Science, 23*(3), 239-254. https://doi.org/10.1080/10888691.2017.1398090

Radhakrishna, R., & Bowen, C.F. (2010). Viewing Bennett's hierarchy from a different lens: Implications for Extension program evaluation. *Journal of Extension 48*(6). https://www.joe.org/joe/2010december/tt1.php

Rice, J. E., Rugg, B., & Davis, S. (2016). Minnesota 4-H Science of Agriculture Challenge: Infusing agricultural science and engineering concepts into 4-H youth development. *Journal of Extension, 54*(3). https://www.joe.org/joe/2016june/iw4.php

Riley, D., & Butler, A. (2012). *Priming the pipeline: Lessons from promising 4-H science programs*. Policy Studies Associates, Inc.

Ripberger, C., & Blalock, L.B. (2013). Training teens to teach agricultural biotechnology: A national 4-H science demonstration project. *Journal of Youth Development, 8*(3). https://doi.org/10.5195/jyd.2013.84

Sage, R., Vandagriff, J., & Schmidt, J. (2018). Building life skills and interest in STEM through rural 4-H robotics camps. *Journal of Human Sciences and Extension, 6*(1), 18-35. https://www.jhseonline.com/article/view/644/557

Saldaña, J. (2014). Coding and analysis strategies. In P. Leavy (Ed.), *The Oxford handbook of qualitative research* (pp. 581-685). Oxford University Press. 10.1093/oxfordhb/9780199811755.013.001

Sallee, J., Cox, R.B., Flores, R., Cooper, S.R., Gomez, B.I., Gifford, C.A., & Hernandez-Gifford, J. (2019). Linking experiential workshops and increased STEM interest among first- and second-generation Latino youth. *Journal of Youth Development, 14*(1), 198-215. https://doi.org/10.5195/jyd.2019.581

Strauss, A. L. (1987). *Qualitative analysis for social scientists*. Cambridge University Press.

Teddlie, C. & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences*. Sage.

Turnbull, B.J. (2013). *The 4-H science initiative: Summary observations from an evaluation*. Policy Studies Associates, Inc. https://4-h.org/wp-content/uploads/2016/02/4-H-Science-Initiative-PSA-Summary-Report.pdf

Veleva, V., Parker, S., Lee, A., & Pinney, C. (2012). Measuring the business impacts of community involvement: The case of employee volunteering at UL. *Business and Society Review, 117*(1), 123-142. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-8594.2011.00395.x

Worker, S.M., Schmitt-McQuitty, L., Ambrose, A., Brian, K., Schoenfelder, E., & Smith, M.H. (2017). Multiple-methods needs assessment of California 4-H science education programming. *Journal of Extension*, *55*(2). https://www.joe.org/joe/2017april/rb4.php

Worker, S. M., & Ching, C. C. (2016). Examining tensions among youth, adults, and curriculum as co-designers in 4-H STEM learning through design programs. In C.K. Looi, J.L. Polman, U. Cress, & P. Reimann (Eds.). *Transforming learning, empowering learners: The international conference of the learning sciences* 2016, Volume 1. International Society of the Learning Sciences.