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Fitting the Framework: The STEM Institute and the 4-H Essential Elements

Abstract

Extension and 4-H youth development programs are addressing a shortage of scientists, engineers, and other related professionals by promoting science, technology, engineering, and math (STEM). This case study illustrates how the Oklahoma 4-H Youth Development program trained youth-adult teams to design and implement STEM projects. The STEM Institute incorporated the 4-H Eight Essential Elements to structure programming. Using the Essential Elements framework helped ensure quality STEM programming, participant retention, and successful community projects lead by youth leaders. The most successful projects were youth driven and adult facilitated, used local partners, and took time to develop.

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Introduction

> *"Our nation's young people are not acquiring the skills they need to excel in the fields of science, technology, engineering and math. That needs to change if we want to build a generation of workers who will make America a leader in innovation. Given the opportunity, today's youth can step up, become engaged, learn more, and become the inventors, rocket scientists and engineers of the future."*
>
> *Donald T. Floyd, CEO and President of the National 4-H Council (Sridhar, 2013)*

In the 21st century, Extension is addressing a shortage of scientists, engineers, and other related professionals throughout the United States by promoting Science, Technology, Engineering, and Math (STEM). As part of Oklahoma State University, the Oklahoma 4-H Youth Development program uses an educational, service-based approach to encourage youth to explore scientific fields and careers. Framing the program in the 4-H Eight Essential Elements provides the structure necessary to help ensure initial participant success and retention. This article fills a gap in the literature in that it provides a case study presented in the framework of the 4-H Eight Essential Elements. This effort

moves from theory to application and provides tips to help ensure program success.

Why Do We Care?

4-H supports STEM education. The Oklahoma 4-H STEM Institute is novel in that it combines contemporary science programming, youth-adult science skills mentoring, and an introduction to science-related careers for youth participants. The purpose of the Oklahoma 4-H STEM Institute is to give youth the opportunity to learn new skills, apply technology, work with community organizations, explore STEM based careers, and work as a facilitated team. The 4-H Eight Essential Elements are incorporated throughout the process.

4-H Essential Elements

The Eight Essential Elements have been identified and incorporated into the 4-H program in 2009 (Mincemoyer, Nestor-McNeeley, & Martz, 2009). Through 4-H projects, youth master skills and make positive career and life choices (Eccles & Gootman, 2002, pp. 86-120). Some elements may help youth generate positive outcomes, preparing for adulthood and reducing risky behaviors (Eccles & Gootman, 2002, pp. 86-120; Search Institute, 2006). Youth develop self-confidence by successfully solving problems and meeting challenges. This is best accomplished in a safe, participatory environment. Youth pursue topics they find most interesting in a safe environment (Kress, 2004).

The Eight Essential Elements are as follows:

- Positive relationship with caring adult
- Safe environment
- Inclusive environment
- Engagement in learning
- Opportunity for mastery
- Opportunity to see oneself as an active participant in the future
- Opportunity for self-determination
- Opportunity to value and practice service for others (4-H, April 2011).

The Essential Elements and STEM

The Eight Essential Elements provide a strong framework for STEM education. Using the Elements, project leaders can structure STEM programing to ensure participant satisfaction and success. As noted by Mielke and Sanzone, high quality science programs must demonstrate certain characteristics. These qualities include inquiry, experiential learning, skills development, leadership, and positive development (Mielke & Sanzone, 2012, p. 7). All of these aspects may be met when

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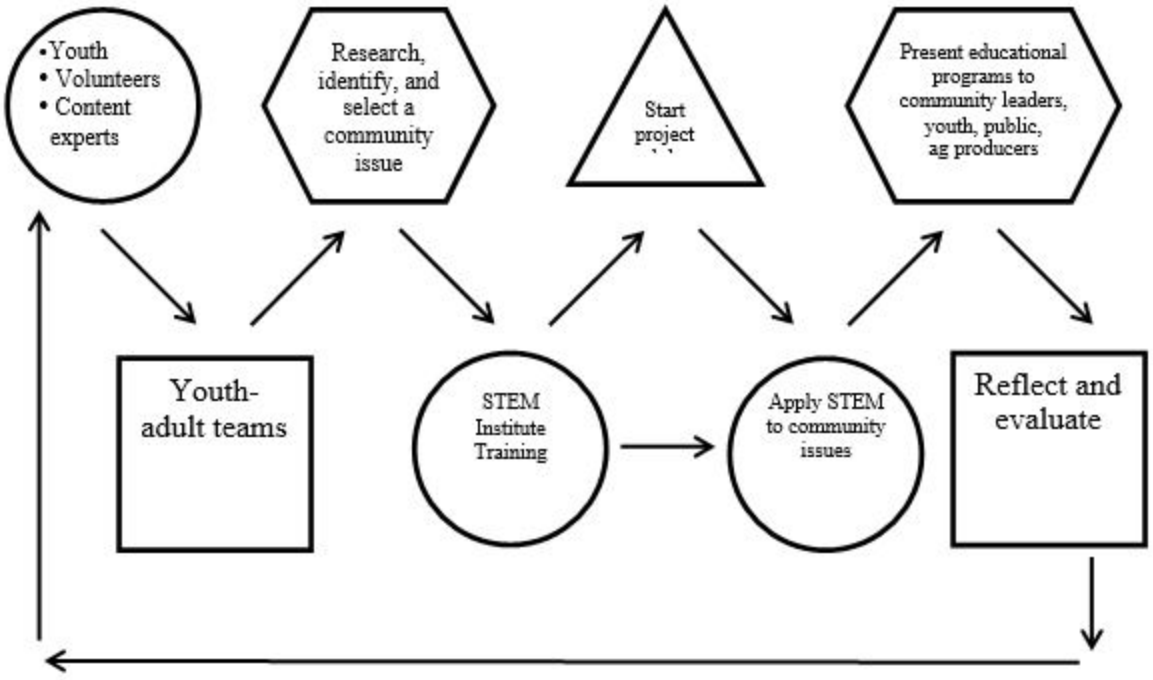
STEM programming is structured in the context of the Eight Essential Elements.

The Oklahoma 4-H STEM Institute

The Oklahoma 4-H STEM Institute began in 2008. Teams of youth and adults worked with university faculty, who serve as group mentors. The university faculty mentors are recruited through informal networks for their technology and application expertise. Faculty are excellent program presenters, delivering quality programming in their content area (Locklear, 2013). Initially, the STEM Institute was developed to teach teams about GPS/GIS projects related to the ESRI 4-H grant program (ESRI, 2013). This program generated qualitative evidence that a similar format would work for other content. Based upon demand, additional tracts (digital media, environment, alternative energy, and forensics) were later developed and added.

With the guidance of the local educator, each team chose a tract. The teams came to campus to attend in-depth, 2-day training provided by both resident and Extension faculty. Each team received a total of 16 initial contact hours in the chosen subject matter. Teams then returned to their communities to apply knowledge gained. Projects were deemed complete once teams returned to their home communities and implemented a project. Project implementation represents community change, which empowers the youth (Zeldin, 2004). Figure 1 illustrates the process by which students, adults, county educators, and faculty combined to form and participate in the STEM Institute.

Figure 1.
STEM Institute Structure



Since 2010, the STEM Institute has trained 75 youth-adult teams in five unique tracts as indicated in Table 1: (1) Geospatial GPS/GIS, (2) digital media, (3) Lego robotics, (4) environmental conservation, and (5) forensics. Significantly, all tracts are hands-on. Very little time spent was

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spent in a formal classroom setting. Table 1 provides information about the STEM Institute planning process.

Table 1.

The STEM Institute Planning Structure

Tract		Years Offered	Short-Term Outcome	Planned Outcomes	Number Trained
1	Geospatial GPS/GIS	2008-12	Create maps	Maps were used to educate the public about issues such as storm shelter locations, historical sites, or even used to locate and identify illegal dumps sites.	n = 17
2	Digital media	2010-12	Create videos to educate the public about youth-selected issues	Videos have been developed and used to teach other youth and the public about topics such as; bullying, distracted driving, issues facing military youth, 4-H promotion, and therapeutic horse programming	n = 28
3	Lego robotics	2010-12	Start robotics clubs and teach youth about engineering	Teams have competed in the Lego Robotics and Botball competitions, studied and/or promoted robotics as 4-H club projects	n = 11
4	Environmental conservation	2011-12	Build rain gardens, start recycling programs, and teach alternative energy	Teams have installed rain-barrels, built rain gardens, taught the 40 Gallon challenge, and started recycling programs.	n = 6
5	Forensics	2011-12	Learn about forensics related to plant science, conduct a forensic investigation	Teach forensics to other youth and start forensic 4-H clubs.	n = 13
				Total trained	N = 75

Following are the results from the 2012 STEM Institute. Each description features one example of an outstanding project or one with greatest potential to make a long-term impact.

The Five STEM Institute Tracts

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Tract 1: Geospatial GPS/GIS

The geospatial tract is the longest running and most successful tract of the STEM Institute. Participants learned to use global positioning systems (GPS) to identify data to be used in making geographic information systems (GIS) maps. Youth projects have mapped locations for historical societies (e.g., ghost towns) and fire hydrants and storm sirens for fire departments. Each map was created for public use. Maps have been distributed at venues including grocery stores, fire departments, and Christmas light displays. Success was measured by creation and use of maps.

Tract 1 Example: Comanche County

The 2012 Comanche County team leaders (n=3) used critical thinking and problem-solving skills to create a map and route for "Holiday in the Park" light display in Lawton, OK, an important public/private annual event. The data used to inform the map were collected during the annual 4-H GPS Hike. Teen STEM Institute leaders provided a GPS educational program to 35 youth and adults program participants. Several viewed the opportunity as family quality time. The final map was shared with the Lawton Parks and Recreation "Holiday in the Park" Light Committee. The youth will continue to map "Holiday in the Park."

Tract 2: Digital Media

The Digital Media tract provided the education participants needed to create videos and other digital media. The purpose was to help participants identify youth-relevant issues, create appropriate media, and distribute to the public. Video is effective at harnessing youth voices and telling their story (Education Development Center, 2012). STEM Institute digital media projects have focused on bullying, making better grades, the dangers of distracted driving, drinking and driving, and community service.

Tract 2 Example: Jackson County

The 2012 Jackson County team (n=5) created their media piece, "The Clover Corner Newscast." Their newscast highlighted the history of 4-H and the land-grant system, 4-H trivia, county events, and community service. The project effectively transitioned county promotional efforts from radio to video. The video was shown at the county 4-H awards program. The team used social media to make a larger impact by posting it on the Jackson County 4-H Facebook page.

Tract 3: Lego Robotics

As noted by Barker and Ansorge (2006), Lego robotics are an efficient means of promoting STEM to youth. In 2012, five teams participated in the OSU STEM Institute Lego robotics tract (n = 25). Each team experienced varying success. Three teams added robotics to their local 4-H program. Two teams have started 4-H robotics project clubs. At least two of the five Lego Robotics teams will compete in upcoming First Lego League Competitions.

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Tract 3 Example: Muscogee (Creek) Nation

The Muscogee (Creek) Nation team obtained a Lego NXT Robotic kit and spare parts through the Muscogee (Creek) Nation 4-H program. Parents also purchased an additional kit and became certified volunteers in order to establish the new 4-H Club. This club meets regularly each month and attended the First Robotics Competition to learn more and set future goals.

Tract 4: Environmental Conservation

The Environmental Conservation tract taught participants about resource conservation. The tract featured three components: (1) water, (2) energy, and (3) waste. Youth and adults received education about water management, learning about rain barrels, rain gardens, permeable pavers, solar powered pumps, and how to educate other youth about water conservation by using the 40 Gallon Challenge (http://www.40gallonchallenge.org/). Participants learned about energy management via alternative energy sources. Finally, waste education featured recycling under-recycled resources, including traditional household trash, textiles and household goods, and housing components.

Tract 4 Example: Haskell County

The Haskell County 4-H team partnered with the County Commissioners to install a rain garden/sand cistern and solar powered pump in front of the county Cooperative Extension Service office. The project is designed to water landscape beds. The team has incorporated the 40 Gallon Challenge as a tool to reinforce the water conservation message. Upon completion, this site will serve as a demonstration location to teach youth and families how to conserve water. The County Commissioners have supported the project by sending county workers to help the youth install the cisterns.

Tract 5: Forensics

4-H Forensics is the newest educational tract of the STEM program, started in 2011. The Oklahoma 4-H Youth Development program has partnered with the National Institute of Microbial Forensics, Food and Agricultural Biosecurity (NIMFFAB) to educate youth-adult teams about food security, forensics, crime scene investigation techniques, and even courtroom procedures. This program is pilot testing new curriculum and programs. Twelve teams have participated in this project. These teams have taught limited workshops in their home counties. The goal of starting local 4-H forensic clubs has not yet been reached. Examples of successful projects will be realized most likely in 2014.

Youth, Engagement, Attitudes, and Knowledge Survey Results

Short-Term Results: Knowledge, Awareness, and Attitudes

Immediately following the STEM Institute, youth participants responded to the Youth, Engagement, Attitudes, and Knowledge survey (Mielke, LaFleur, Butler, & Sanzone, 2012). Forty-nine youth participated in the survey, each immediately following one of three 2012 STEM Institute workshops.

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Survey administration followed IRB protocols established at Oklahoma State University IRB #AG 1220. Table 2 provides basic demographics.

Table 2.

Youth Participant Demographics (2012 data)

Characteristic	Range	Frequency	Percent
Age	9-12	15	31
	13-15	27	55
	16-18	7	14
	Total	**49**	**100**
Race (select all that apply)	Hispanic/Latino	4	8
	Native American	11	22
	White	42	86
	Other	2	4
	Total	**59**	**100**
Gender	Boy	29	59
	Girl	20	41
	Total	**49**	**100**

The following indicators (Tables 3-7) suggest that initially, the STEM Institute met the goal of promoting science, technology, engineering, and math to participants. Table 3 illustrates the educational history and goals of the program participants. Ninety-six percent planned to obtain a college degree, 75% of their mothers completed college and/or some graduate school, and 73% had been in 4-H for 3 or more years. These findings indicate a long-term commitment to education, which support the Essential Elements: Engagement in learning, opportunities for mastery, opportunity to see oneself as an active participant in the future, and opportunity for self-determination.

Table 3.

Summary of Youth Participant Educational History and Goals (2012 data)

History or Goal	Range	Frequency	Percent
School type attended	Public	44	90
	Religious	3	6

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	Home	2	4
	Total	**49**	**100**
Educational goals	Graduate from high school	1	2
	Go to a little college	1	2
	Finish college	35	71
	Get more education after college	12	25
	Total	**49**	**100**
Highest level of school your mother went to?	Grade school	1	2
	High school	8	16
	College	30	61
	Another graduate school after college	7	14
	I don't know	3	6
	Total	**49**	**100**
Years in 4-H	First year	4	8
	Second year	9	19
	Three or more years	35	73
	Total	**49**	**100**

The purpose of the STEM Institute was to introduce youth to new science technologies, careers, and opportunities to apply STEM concepts. Table 4 outlines the participants' perceptions of STEM skills. The majority of participants perceive science in a positive light, where they can conduct experiments, solve problems, and learn about careers.

Table 4.

In this 4-H Program or Project, I Can… (2012 data)

Question (I can…)	Strongly Disagree	Disagree	Agree	Strongly Agree	Mean
Do experiments	1	3	30	15	3.20
Do hands-on science activities	1	3	11	34	3.59
Solve problems	3	4	17	24	3.29

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See science in a fun way	0	1	18	30	3.59
Learn about careers	3	5	21	20	3.18
Serve my community	1	2	24	22	3.37
Learn with my friends	0	0	20	29	3.59
Get answers to my questions from leaders	1	3	17	28	3.47
Tell a group of people about something I learned or made	1	2	14	32	3.57
N = 49					

Table 5 indicates the participants' perceptions of the incorporation of the Essential Elements. The majority of participants feel safe, feel included, are positive about the adults, feel encouraged to learn, and have been given opportunities for mastery.

Table 5.

Please Tell Us How Often You Think the Following Things Are True When You Are at This 4-H Program or Project (2012 data)

Question	Never	Sometimes	Usually	Always	Mean
I feel safe and respected	0	4	21	24	3.41
I am afraid I will be embarrassed or put down	32	11	3	3	1.53
All kinds of kids are welcome	1	1	8	39	3.73
Adults listen to what I have to say	1	6	17	35	3.35
I feel comfortable going to adults for advice	0	11	19	19	3.16
Other kids care about me	1	10	18	19	3.15
I feel like I can make a difference	1	7	14	27	3.37
I am encouraged to take responsibility	0	2	16	30	3.58
It is OK to make mistakes	0	4	9	36	3.65
N = 49					

Table 6 outlines participants' perceptions of STEM, as a broader concept. The majority stated that

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science is one of their favorite subjects. They perform science activities for enjoyment and would like a job related to science. Most of the participants indicated they take science for reasons other than they have to or it will help them in the future. These findings illustrate a strong interest in science and participating in future science activities.

Table 6.

Please Indicate the Extent to Which You Agree or Disagree with the Following Statements (2012 data)

Question	Strongly Disagree	Disagree	Agree	Strongly Agree	Responses	Mean
When I graduate from high school, I would like to have a job related to science	1	13	13	20	47	3.11
Science is one of my favorite subjects	3	9	17	19	48	3.08
I do science related activities that are not for schoolwork	3	11	20	12	46	2.89
I take science only because I have to	19	18	8	3	48	1.90
I take science only because it will help me in the future	12	15	12	8	47	2.34

Thus far, the most successful STEM Institute projects resulted in a community action, video, demonstration, club, or map. All of these projects have a strong community service/service learning aspect. Table 7 signifies that most STEM Institute participants have a history of helping with science-related community service projects.

Table 7.

In the Past Year, Have You Done Any of the Following Things? (2012 data)

Question	Yes	No	Responses	Mean	Percent	National findings
Helped with a community service project that related to science (for example: planted trees or gardens, road or stream clean-up, recycling)	39	8	47	1.17	83	70
Used science tools to help the community (for example: mapped with GIS, tested water quality)	19	29	48	1.60	40	33
Taught others about science (for example:	28	20	48	1.42	58	56

demonstrated, gave presentation at community meeting or at school)						
Organized or led science-related events (for example: science fair, environmental fair)	19	29	48	1.60	40	35

Discussion: STEM Institute and the 4-H Essential Elements Criteria

As is evident in the survey questions, the STEM Institute accommodates the Eight Essential Elements. On average, the program (Table 4) and greater context (Tables 5, 6, and 7) are small, initial indicators that the criteria are being supported. Longitudinal data would greatly strengthen any possible relationships between the STEM Institute and participant outcomes.

Regardless, the STEM Institute was successful at supporting the 4-H Eight Essential Elements. The youth were **building relationships with positive, caring adults** as they learned side-by-side with their adult county educators, volunteers, and faculty. The youth-adult partnerships fostered mutuality in learning, teaching, and action, as emphasized by Camino (2000) and Jones and Perkins (2005).

The STEM Institute modeled a **safe environment** where participants were not only protected from harm, but were allowed to express themselves and their ideas freely. The STEM Institute was an **inclusive environment** as it was open to anyone interested in the topics presented. Upon return to home counties, the adult leaders insured that the teams continued to work in safe and inclusive environments established during the STEM Institute.

Participants were **engaged in learning** in that they were able to self-select into a STEM Institute tract, learn as a team, and then participate in a mandatory debriefing session where participants presented their work. Teams attended training, developed a program implementation plan, and worked together upon returning to their home community or county. The teams have embraced the process. By working with other community organizations, the teams discover that they can participate in the future by initiating change and serving on the community level.

Participants are provided an **opportunity for mastery** in that they are able to develop a project based on their campus experience and deliver it in their communities. **Opportunity to see oneself as an active participant in the future** is inherent to the STEM curricula. **Opportunity for self-determination** is presented though self-reflection, goal setting, and project achievement. Finally, the **opportunity to value and practice service for others** is fulfilled as students return to their communities to provide a meaningful service based on their STEM Institute experience.

Conclusion

Between 2008 and 2012, a total of 78 teams have participated in the STEM Institute. Participants included 128 adults and 274 youth. Faculty and staff provided expertise in tracts, with many returning from year to year to ensure continuity. The 4-H STEM Institute has trained youth-adult teams and challenged them to design and implement science, technology, engineering, and math projects. The most successful projects are youth-driven and adult-facilitated, use local partners as

mentors or funders, and may take a year or longer to develop. The STEM Institute has effectively given participants the knowledge and confidence needed to return to their home communities and start STEM-based clubs. Participants apply their newfound knowledge towards community service and enhancement.

The STEM Institute may play a role in encouraging youth to become part of the next generation of STEM professionals. If faculty, staff, volunteers, or youth want to replicate the STEM Institute, consider using the 4-H Eight Essential Elements as the framework to structure programming. Using the Eight Essential Elements framework will help ensure quality STEM educational programs, participant retention, and successful community projects led by youth leaders.

References

4-H. (April 2009). *Essential elements*. Washington, DC: 4-H National Headquarters.

Barker, B. S., & Ansorge, J. (2006). Using robotics as an educational tool in 4-H. *Journal of Extension* [On-line], 44(5) Article 5IAW6. Available at http://www.joe.org/joe/2006october/iw6.php

Camino, L. A. (2000). Youth-adult partnerships: Entering new territory in community work and research. *Applied Developmental Science*, 4(S1), 11-20.

Eccles, J., & Gootman, J. (Eds.). (2002). *Community programs to promote youth development*. Washington, D.C.: National Academy Press.

Education Development Center. (2012). Findings from 5 years of the Adobe Youth Voices Program Evaluation. Retrieved from: http://youthvoices.adobe.com/impact/

ESRI. (2013). 4-H and GIS. Retrieved from: http://www.esri.com/industries/k-12/4-h

Jones, K. R., & Perkins, D. F. (2005). Youth-adult partnerships. In C. B. Fisher & R. M. Lerner (Eds.), *Applied developmental science: An encyclopedia of research, policies, and programs*. Thousand Oaks, CA: Sage Publications.

Kress, C. (2004). Essential Elements of 4-H Youth Development. Retrieved from: http://www.national4-hheadquarters.gov/library/Essential_Element-Satellite.ppt

Locklear, E. L. (2013). 4-H science initiative from inception to impact: Methodologies, lessons learned, best practices and recommendation. Retrieved from: http://www.4-h.org/youthstem/

Mielke, M., LaFleur, J., Butler, A., & Sanzone, J. (2012). *4-H science initiative: Youth engagement, attitudes, and knowledge study*. Washington, DC.

Mielke, M., & Sanzone, J. (2012). *4-H science evaluation: Year 3 implementation study*. Washington, DC.

Martz, J., Mincemoyer, C., & McNeeley, N. (2009). *Exploring the Essentials Elements of 4-H*. Washington, DC: National 4-H Council.

Search Institute. (2006). *40 developmental assets for adolescents*. Retrieved from:

http://www.search-institute.org/developmental-assets/lists

Sridhar, S. (2013). Meet national 4-H council president Donald T. Floyd: Advancing STEM education, its future. Retrieved from: http://www.washingtonexec.com/2013/01/meet-4-h-council-president-donald-t-floyd-advancing-stem-education-its-future/

Zeldin, S. (2004). Youth as agents of adult and community development: Mapping the processes and outcomes of youth engaged in organizational governance. *Applied Developmental Science*, 8(2), 75-90.

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