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Kentucky 4-H Minimizes Barriers to STEM Education

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DEDICATION

William C. Noble and Darlene J. Noble, the most selfless and loving parents.

Thank you for being my greatest supporters and loving me unconditionally.

You’ve inspired me to reach for my dreams, all that I accomplish I owe to you.

ACKNOWLEDGEMENTS

Thank you to the Kentucky 4-H Program and the continual effort by former and current professionals and volunteers to empower youth to reach their full potential.

ABSTRACT

Science, Technology, Engineering, and Math (STEM) programs are a national priority. The increase in the number of jobs that require a STEM-minded workforce raises the demand for education systems and communities to focus on fostering the development of STEM competencies of students. American youth are not gaining the skills necessary to compete in the global workforce. This study investigates how Kentucky 4-H minimizes the barriers of accessing STEM programs for youth in grades 4 through 8. Barriers of accessing STEM programs investigated are: lack of funding and resources, time, professional development, integration across curriculum, and out-of-school experiences. 4-H is the largest youth development organization in the world. Areas of national focus in 4-H curriculum include: STEM, agriculture, citizenship, and healthy living. This study surveyed all 120 Kentucky counties via an online questionnaire in October 2017. Sixty-five county-based 4-H professionals responded. The instrument contained Likert-type and investigative questions probing STEM-related programming offered within the county 4-H program. Questions within the instrument investigated the use of national science standards, national 4-H standards, and barriers identified through existing literature. The study found that 4-H professionals implement the use of national science curriculum and 4-H curriculum as they offer STEM programming within their county, which is predominately funded by Cooperative Extension monies. 4-H programs utilize experiential learning approaches through interdisciplinary lessons in STEM that empower youth to develop competencies related to the *Essential Elements of*

Positive Youth Development, *The Engineering Design Process* and *The Experiential Learning Model.* This research can be utilized in the future to expand STEM programming opportunities for youth in Kentucky.

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Employment opportunities in occupations related to science, technology, engineering, and mathematics (STEM) is projected to grow to more than nine million between 2012 and 2022(Bureau of Labor Statistics, Occupation Outlook Quarterly, 2014). By 2018, approximately 2,800,000 jobs will open in STEM professions (Schroeder, et al., 2013). Employment trends show that there is a need for a technology and science-minded workforce, especially as our world becomes more globalized. However, students in the United States are not graduating high school ready to enter post-secondary education prepared to study, or enter the workforce with necessary job skills, that could lead to a career in STEM (Barker, Larson, & Krehbiel, 2014). A deep-rooted passion for science and math begins at an early age. The statistics are astonishing. Only four percent of the United States' workforce is composed of scientists and engineers (Barker, Larson, & Krehbiel, 2014). That small percentage disproportionately creates jobs for the other ninety-six percent of the working population (Barker, Larson, & Krehbiel, 2014).

Our nation's young people are not acquiring the skills they need to excel in STEM fields (Sallee & Peek, 2014). This trend needs to change if the United States wants 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 (Sallee & Peek, 2014).

The Next Generation Science Standards (2013) (NGSS) focus on integrating engineering concepts into American public schools as early as third grade. The NGSS require teachers to focus on various topics within STEM, building onto components from year to year. Throughout each grade level NGSS focuses on: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science (Next Generation Science Standards, 2013). With each developmental stage more complex concepts are introduced.

Although the United States has core concepts in place to focus on promoting a workforce that is innovative enough to compete in the global workforce, there are numerous barriers that inhibit educators from fully implementing the innovative curriculum that is required of STEM. Through the study of the literature, barriers inhibiting access to STEM education are: instruction time, funding, professional development, and access to resources.

Only five percent of learning that occurs over a person's lifespan takes place inside a traditional classroom (formal), leaving ninety-five percent to out-of-school settings (non-formal) (Worker & Mahacek, 2013). More communities are focused on the time students spend out-of-school to provide experiential lessons they may not have the opportunity to experience in the formal classroom setting. Current research indicates that out-of-school time programs can be effective avenues for promoting learning in science, technology, engineering, and math content areas (Barker, Larson, & Krehbiel, 2014).

Figure 1 shows the impact of out-of-school time and science, technology, engineering, and math. Over the course of a year, only 18.5% of K-12 students' waking hours are spent in school (Schroeder, et al. 2013). Therefore, maximizing quality time spent on incorporating STEM concepts in formal and non-formal education settings is vital to the success of preparing a STEM-minded workforce. It is perceived that advantages of STEM education include: significant increases in student achievement, creation of the next generation of STEM professionals, concepts are more motivating, exciting, and interesting to students, students are better prepared for the workforce, students experience improvement of quality of learning related to concepts (Heil, Pearson, & Burger, 2013). To provide a more robust learning environment, within non-formal and formal settings, educators must identify ways students can connect to STEM and plan integrated projects based on those student needs. Figure 2 shows ways educators can attract youth to STEM education and experiences.

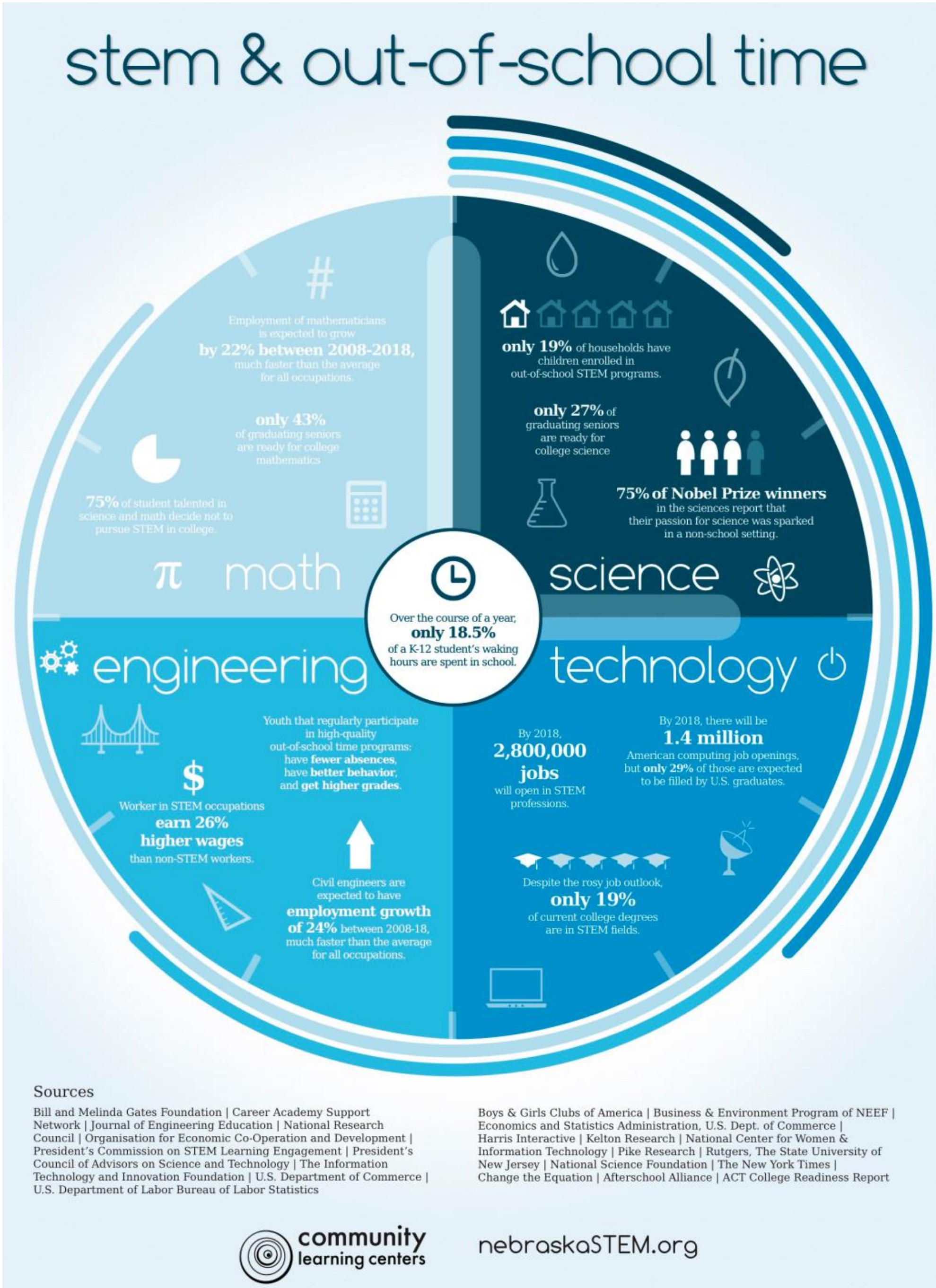


Figure 1: STEM & Out-of-School Time. *Source*: Schroeder, K., Woodland, J., Lang, C., Barker, B., Mulkerrin, E., Novotny, J., Williams, G., Krishnamurthi, A., Noam, G., & Ottinger, R. (2013). STEM & out-of-school time. Retrieved from http://netnebraska.org/basic-page/learning-services/out-school-time-and-stem.

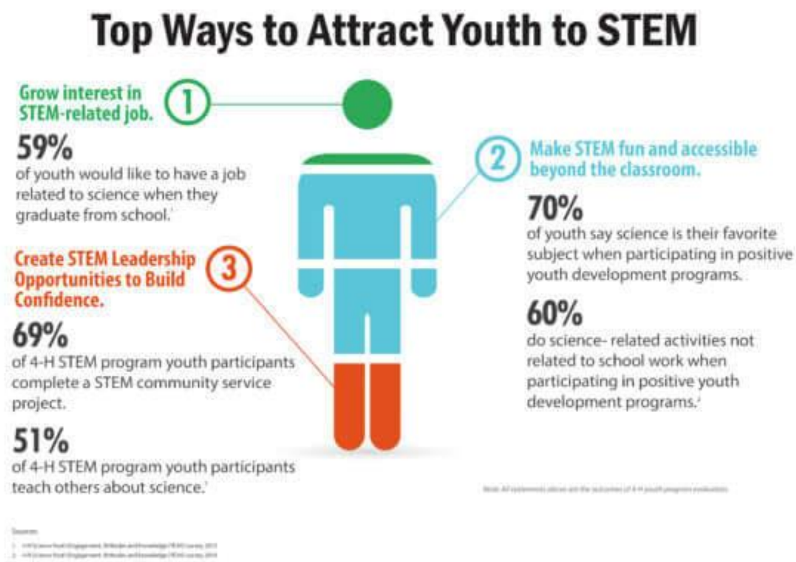


Figure 2: Top Ways to Attract Youth to STEM. *Source*: Top Ways to Attract Youth to STEM. (n.d.) (2017, March 22). Retrieved from http://4-h.org/about/research/#!science.

Definition of Key Terms

Science, Technology, Engineering, and Math (STEM): STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply STEM in contexts that make connections between school, community, work, and the global enterprise. Thus, enabling the development of STEM literacy, and with it, the ability to compete in the new economy (Tsupros, 2009).

4-H Youth Development: 4-H is a community of young people across Kentucky who are learning leadership, citizenship, and life skills. 4-H empowers youth to reach their full potential by developing skills to succeed in today's global society (Kentucky 4-H, 2016). The 4-H program was one of the first youth-focused organizations to employ non-formal education as a means to reach youth (Van Horn, Flanagan, and Thomson, 1998). 4-H is the youth branch of the

Cooperative Extension Service, a federally funded program. In the United States, 4-H programs empower six million young people through the 109 land-grant universities and Cooperative Extension in more than 3,000 local offices serving every county and parish in the country (National 4-H Council, 2015).

Cooperative Extension Service: The Smith Lever Act of 1914 was instrumental in establishing the Cooperative Extension Service as the main vehicle for delivering new developments in agriculture, home economics, and related subjects to farmers, homemakers, and youth from the land-grant university of the state (APLU, 2012; Conglose, 2000).

Delivery Modes: 4-H reaches youth through a variety of delivery modes, which is the learning environment in which programming is conducted. The federally mandated delivery modes are: school enrichment, school clubs, projects/project clubs, community clubs, and SPIN (special interest) clubs (Kentucky 4-H, 2013). Kentucky 4-H views a quality educational experience where youth advance their understanding should contain six hours of education (Kentucky 4-H, 2017).

Non-formal education: Non-formal education is based on a commitment to learning and knowledge acquisition, and therefore relies on carefully designed and scientifically sound curriculum and resources. Non-formal education may use clubs, camps, group meetings, sporting or arts activities, or youth-led events to carry out educational work. Non-formal education occurs in diverse locations and varies based on youth interest and community needs, leading to community-based and youth-driven experiences led by professionals, volunteers, and other youth.

Non-formal education recognizes and awards youth for their achievements and accomplishments without formal testing (Russell, 2001; Walker & Dunham, 1996; Walker, 1998).

Formal education: Formal education is based on a commitment to learning and knowledge acquisition, it relies on carefully designed and scientifically sound curriculum and resources. Formal education is based in a school building or similar structured environment, led by certified teachers, and follows standardized guidelines. Formal education tests and grades individuals on knowledge obtained through lessons taught in the educational settings (Russell, 2001; Walker & Dunham, 1996; Walker, 1998).

Purpose

The purpose of this study is to identify if the Kentucky 4-H Program minimizes the barriers of accessing science, technology engineering and math programs for youth in grades 4-8. Focused STEM programming has been offered in Kentucky 4-H beginning ten years ago when the National 4-H Mission Mandates (Locklear, 2013) identified the need for more STEM programming. Kentucky 4-H uses curriculum involving the following STEM areas: geospatial, bio-technology, robotics, aerospace, energy/electricity, petroleum power, and computer science. This study investigates which programs are being utilized across the Commonwealth and if those programs minimize the barriers to STEM programs for all Kentucky youth.

Significance

Science, technology, engineering, and math (STEM) education is an area of frequent discussion for educational professionals in the United States. Technology has changed and will continue to change the world. More individuals are needed to fill jobs, and the United States education system is not equipping youth with the skills necessary to seek these STEM-based careers (U.S. Department of Education, 2016). For STEM education to achieve its goals and objectives, addressing the barriers to STEM education should start by addressing the problems at the elementary, junior and senior high school levels (Ejiwale, 2013). Identifying the barriers to providing STEM programs inside and outside of school is imperative to closing the gap of an ill-equipped workforce (Schroeder, et al., 2013).

This study aims to identify if the Kentucky 4-H Program minimizes the barriers to access science, technology engineering and math programs for youth in grades 4-8. The Cooperative Extension Service, funded through the United States' land-grant colleges and universities, is addressing a shortage of science, engineers, and other related professions through the United States, by promoting STEM programs (Sallee & Peek, 2014). The results of this study may be used to advocate for involving 4-H youth development education professionals in both formal and non-formal sectors, to provide a more collaborative learning experience related to STEM for students in grades 4-8 in Kentucky. It is essential that formal and non-formal educators focus on an integrative approach of STEM education. Through integrating various key concepts from 4-H curriculum, formal educators will be able to maximize in school time of students. By partnering with 4-H, non-formal educators will reinforce core curriculum in out-of-school time through hands-on learning in 4-H youth development programs.

II. Literature Review

The focus on Science, Technology, Engineering, and Math (STEM) education has increased substantially over the past several years. The emphasis on STEM education can be credited to the increase in demand of STEM related jobs in the United States workforce and the interconnection and advancement of our global society. Between 1960 and 2011, the number of workers in science and engineering occupations grew at an average annual rate of 3.3%, greater than the 1.5% growth rate for the total workforce (National Science Foundation's Science and Engineering Indicators, 2016). Although the need for professionals in the STEM workforce has increased, there are several shortfalls in preparing students to fulfill that need in the United States. The United States is falling behind internationally, ranking 29th in math and 22nd in science among industrialized nations (U.S. Department of Education, 2016). Due to these shortfalls, President Obama launched the "Educate to Innovate" Campaign in November 2009 with the purpose of making STEM education a priority among schools in the United States. The goal of this campaign was that, within a decade, American students would move from the middle to the top of the pack in science and math (Educate to Innovate, 2016).

Fostering the development of STEM education in K-12 schools in the United States should be a priority for all Americans. Excellence in STEM education can impact jobs, productivity, and competitiveness in multiple sectors and fields including health, technological innovation, manufacturing, the distribution of information, political process, and cultural change (Asunda, 2014;

Peters, 2006; Shernoff et. Al., 2017). STEM education focuses on experiential learning where students gain skills and knowledge on how to solve tough problems, gather and evaluate evidence, and make sense of information (U.S. Department of Education, 2016). Increasing demands in workforce requirements means that the next generation of workers will need even more sophisticated skills in science, technology, engineering, and mathematics (Nugent, Kunz, Rilett, & Jones, E., 2010). Adapting to new and evolving science standards in schools, balancing funding, preparation of educators, integration across the curriculum, ensuring student involvement, linking concepts to career pathways and providing out-of-school experiences are all major aspects of promoting STEM education in the United States.

The Next Generation Science Standards (NGSS) were released in April 2013 and focus on four domains of education related to science: physical sciences, life sciences, earth and space sciences, engineering, technology, and applications of science (Next Generation Science Standards, 2016). The NGSS framework begins its focus on science education in Kindergarten and follows students through 12th grade. According to Academic Benchmark, states that have adopted the NGSS include: Arkansas, California, Connecticut, Delaware, Illinois, Iowa, Kansas, Kentucky, Maryland, Michigan, New Jersey, Nevada, Oregon, Rhode Island, Vermont Washington, and West Virginia (Next Generation Science Standards, 2016). Ninety-three percent of reporting education supervisors (42 out of the 50 states) indicated that they include some form of technology and engineering education in their state frameworks, regardless of whether the school has adopted NGSS (Moye, Dugger, & Starkweather, 2012). This data shows that science and math education is a priority in a majority of schools across the United States, regardless of adopting NGSS.

Funding is a major component when incorporating STEM education in United States schools. Moye, Dugger & Starkweather (2012) report in their study of forty-two states, funding for technology and engineering programs comes from a combination of federal, state, and local monies. DeJarnette (2012) revisits the "Educate to Innovate" campaign and focuses on collaboration between federal government, leading companies, non-profit groups and educational societies as leading entities in progressing STEM education among the nations young people. In the "Educate to Innovate" campaign, the national campaign to produce more STEM-minded students, investors including: Intel, UTeach Program, Public University Presidents, PBS and Woodrow Wilson Teaching Fellowships. These public and private entities have collectively committed $250 million to help prepare over 10,000 new math and science teachers and to train over 100,000 existing teachers in STEM concepts (Educate to Innovate, 2016).

Professional development for educators is key to providing a high quality STEM education framework in K-12 schools. Teachers must be confident in their ability to integrate STEM into their classrooms. Teachers in elementary classrooms need to understand how to teach concepts of STEM related to scientific inquiry, problem-based learning, engineering design and technology activities (DeHarnette, 2012). Although the idea of STEM education has been contemplated since the 1990s in the USA, few teachers seemed to know how to operationalize STEM education several decades later (Kelley, & Knowles, 2016). To meet the needs of the American workforce in filling STEM careers, preparation must begin in the primary and secondary levels by teachers, but the roadblock often occurs when teachers lack funding or professional development opportunities to promote STEM related learning (Nugent, Kunz, Rilett, & Jones, 2010). Research shows that teaching STEM is enhanced when the educator has sufficient content knowledge and domain pedagogical content knowledge (Nadelson, Seifert, Moll, & Coats, 2012). Due to the integrative nature of STEM programs, teachers must feel confident in linking STEM concepts across curriculum, applying STEM lessons to the real world, and building lessons that have an experiential learning component for students to gain hands-on experience. Teacher self-efficacy is pertinent in the conversation of providing more STEM programs within formal education settings.

In most United States schools, STEM is still mostly science and mathematics, taught separately with little or no attention to technology and engineering (Hoachlander, & Yanofsky, 2011). Most teachers have received training in only one discipline and most schools and classes, at all levels, still have separate departments and class periods for STEM subjects. This provides significant challenges to promoting a STEM-minded workforce (Shernoff, Sinha, Bressler, & Ginsburg, 2017). Students interested in a STEM career field should have understanding and knowledge in all fields of study to cross-reference and apply their critical thinking skills in order to problem solve. STEM should not be a stand-alone topic of study, but rather an integrative approach to solving real-world issues. Linked learning pathways can help focus curriculum that connects abstract academic concepts to concrete applications (Hoachlander, & Yanofsky, 2011). Kennedy and Odell (2014) indicated that STEM education programs of high quality should include (a) integration of technology and engineering into science and math curriculum at a minimum; (b) promote scientific inquiry and engineering design, include rigorous mathematics and science instruction; (c) collaborative approaches to learning, connect students and educators with STEM fields and professionals; (d) provide global and multi-perspective viewpoints; (e) incorporate strategies such as project-based learning, provide formal and informal learning experiences; and (f) incorporate appropriate technology to enhance learning (Kelley, & Knowles, 2016).

Student involvement in learning reinforces concepts and aides in long-term retention of information. Youth should be active agents in their own socialization (Jackson, 2014). Students who are exposed to STEM fields are more likely to pursue a STEM profession. Student participants in *Project WISE: Working in Informal Science Education* who were initially undecided about the careers they might pursue, but had a significantly greater interest with respect to several STEM fields: biology, chemistry, engineering, geology, and physics (DiLisi, McMillin, & Virostek, 2011). The National Board (2010) reports a strong correlation between students who take advanced science and math courses in high school and their enrollment and success in four-year postsecondary institutions (DeJarnette, 2012). Along with focusing on high school students, DeJarnette (2012) suggests through the *Partnership for 21st Century Skills*, students should be exposed to interactive problem-solving skills and critical thinking at the elementary level through hands-on learning. If students are exposed earlier to STEM concepts, they will be more likely to enroll in STEM-related courses in middle and high school (DeJarnette, 2012).

Experiential learning is a cornerstone to STEM education's success. Students need to be given the opportunity to construct their own knowledge and expertise by problem-solving and critical thinking through procedural and pedagogical methods that encourage and support inquiry (DeJarnette, 2012). In short, students need to participate in science by hands-on experiments rather than learning the theory without developing concrete understanding of how the theory works. For example, Hoachlander and Yanofsky (2011) found that students' motivation to learn and retain mathematical concepts increased by project-based activities such as designing a wind-turbine or building a combination lock. In Yocom de Romero's second grade classroom, they found that engineering is where students get to make learning their own; it takes them beyond basic comprehension and forces them to do higher-order thinking, such as applying their science knowledge, analyzing data, and evaluating their designs all while increasing their motivation to learn (Morgan, et al., 2012). One draw back in several classrooms is the need for more time to increase the level of experimental learning related to STEM education.

Encouraging experiential learning opens students' minds to real-world application and career exploration. DiLisi, McMillin and Virostek (2011) completed the *Project WISE Program,* where high school students were paired with undergraduate students to implement a project based on STEM concepts and then present that project at a museum for K-5th graders to visit. This project provided an opportunity for high school students to develop a project with a mentor, make decisions based on their project, meet with STEM professionals to critique the project, then educate younger students on their work (DiLisi, McMillin, & Virostek, 2011). These students experienced first-hand what it was like to link their interests in the STEM field to a real-world experience or a future profession. Students also learned the value of communicating their work on a small and large scale. The project incorporated networking students, which fostered the development of relationships with professionals and like-minded peers, providing confidence and support for their choice to participate.

Hands-on learning allows students the opportunity to experience STEM in real-time. Nugent, Kunz, Rilett and Jones (2010) conducted a program where teachers collaborated with the University of Nebraska-Lincoln College of Engineering and College of Education and Human Sciences to increase teacher's knowledge of STEM fields, how to incorporate concepts into their curriculum, and how to inspire students to become involved in STEM projects. The outcome of this study found that teachers significantly increased their knowledge of engineering, developed more positive attitudes towards technology, increased their self-efficacy in using and development of technology-based lessons, and increased their confidence in teaching math and science (Nugent, Kunz, Rilett, & Jones, 2010). Eighty-six percent of teachers who participated in the hands-on learning experience in this study either agreed or strongly agreed that they learned something from the lessons and activities, seventy-five percent reported that the lessons were interesting. All lessons in this study were picked because of their real-world application to what students in K-12th grades would find most interesting (Nugent, Kunz, Rilett, & Jones, 2010). As with this study and many others, time is the factor that inhibits the in-depth learning experience for many students.

Five percent of learning over a person's lifespan takes place inside of a classroom, leaving ninety-five percent to out-of-school settings (Worker & Mahacek, 2013). Many non-profit, non-formal education groups are meeting the needs of STEM education in local communities; one of which is 4-H. 4-H is administered across the United States as a part of the Cooperative Extension System, land-grand colleges and universities (APLU, 2012; Conglose, 2000). For more than one hundred years, the goal of the Cooperative Extension Service has been to improve communities through education infusion. The Extension System's idea was to quickly move knowledge from the laboratory and university into communities (Kress, 2014). 4-H is committed to building outstanding leaders with marketable skills to succeed in today's global society, 4-H empowers youth to reach their full potential, working and learning in partnership with caring adults (Kentucky Cooperative Extension Service, 2015). By 2013, 4-H, a recognized leader in providing hands-on, non-formal learning experiences, will engage one million new youth in a dynamic process of discovery and exploration in science, engineering and technology to prepare them to meet the challenges of the twenty-first century (Locklear, 2013).

In 2007, National 4-H made a commitment to help address STEM education through the 4-H Mission Mandates, which is an effort to engage youth across the country in out-of-school-time science programming that is experientially based, uses inquiry methods, and promotes positive youth development. The goal of these programs is to address the crucial need for more scientists and engineers in the workforce (Worker & Mahacek, 2013). Only four percent of the nation’s workforce is composed of scientists and engineers, this group disproportionately creates jobs for the other ninety-six percent (Barker, Larson, & Krehbiel, 2014).

When the National 4-H Council introduced the National 4-H Mission Mandates in 2007, opportunities were provided for professional development in STEM. Their goal was to create a well-coordinated system of professional development opportunities to better prepare 4-H volunteers and staff to incorporate science, engineering and technology within 4-H. Along with increasing knowledge, skills, competencies and comfort level of 4-H volunteers and staff to offer hands-on, experiential-based 4-H SET learning experiences (Locklear, 2013). The accomplishments of the 4-H Mission Mandates Science Initiative related to professional development includes: engaged a national 4-H SET Professional Development Team to design and implement a comprehensive 4-H SET plan to train state and local 4-H staff and volunteers, initiate webinars and in-person training events to disseminate professional development training and resources, established extensive professional development resources, training materials, videos and self-directed trainings, and promote professional development inside and outside 4-H (Locklear, 2013).

Overhauling 4-H curriculum was a major aspect of the 4-H Mission Mandates. 4-H needed to update and create experiential and problem-based lessons that could be packaged and facilitated by either 4-H professionals or volunteers. This was crucial in the effort to reach the goal of one million new youth involved in science discovery. National 4-H Council accomplished those goals by: developing a multi-year 4-H SET curricula plan (with assistance from STEM curriculum experts from inside and outside of the 4-H system), developing a 4-H SET rubric/template to ensure that 4-H SET curricula met National Science Education Standards, reviews and revised curriculum, and providing resources for professional development (Locklear, 2013).

A major aspect of any Cooperative Extension Program is funding. The National 4-H Council ensured through the National 4-H Mission Mandates that professionals across the country had the ability to fund STEM programs. Accomplishments related to fund development included working with the Osborne Group to create the Fund Development Toolkit, which included over 250 learning modules, templates and resources to enhance fundraising for 4-H Science). Along with providing a virtual learning environment for 4-H staff and volunteers with all levels of experience in fundraising. Fund development workshops and resources at the National 4-H Science Leadership Academy were also made available as well as assistance with regional academies. Continued education such as webinars before and after national academy to provide fund development education and technical assistance were also resources. Exploration of new business models and revenue streams for curriculum, professional development and other aspects of the 4-H Science Initiative were positive outcomes (Locklear, 2013).

A major aspect of ensuring the success of STEM programs is providing dynamic programs revolving around collaboration and partnerships. National 4-H, through the National 4-H Mission Mandates, helped educators across the United States make connections with partners and contributors. As a result, more than thirty partners helped attain 4-H’s goal of reaching one million new youth with SET programming. Partnerships enabled 4-H Science to access additional youth and volunteers, showcase the 4-H Science Initiative and access STEM experts who serve as mentors, coaches and leaders of 4-H Science work in local communities. 4-H Science continues to explore efficient and effective ways to keep STEM partners engaged with 4-H Science.

As a result of the 4-H Mission Mandates, 4-H professionals, volunteers and youth are making an impact related to STEM-based education across the United States by identifying the local needs of communities and motivating individuals to develop answers to pressing issues. 4-H activities reinforce concepts students learn in school, students are able to develop life skills of creativity, problem solving, design, collaboration, leadership, risk-taking, perseverance, and learning from failure (Horton, & House, 2015). Through non-formal education young people’s learning becomes more meaningful and relevant to them through hands-on experiences (Barker, Larson, & Krehbiel, 2014). The science education community has recognized that young children are capable of higher-level inquiry than previous believed (Horton, Krieger, & Halasa, 2013). As educators, it is imperative to capitalize on the abilities of students in all faucets of learning, formal or non-formal.

Youth who participated in 4-H were more likely to plan to go to college and pursue future courses in computer technology, science or engineering than their peers (Lerner & Lerner, 2012). During the 2016-2017 4-H year in Kentucky, 288,701 youth were enrolled as 4-H members (Kentucky 4-H, 2017). 243,881 Kentucky youth engaged in science in various ways: agriculture in the classroom, animal sciences, environmental education/earth sciences, physical sciences, plant sciences, and technology/engineering (Kentucky 4-H, 2017). Kentucky 4-H aims to promote STEM education through formal and non-formal education settings such as, school enrichment, project clubs, and community clubs.

Extension systems across the United States are focused on developing STEM leaders. California 4-H has focused heavily on promoting science literacy in relation to citizenship. According to Smith, Worker, Ambrose and Schmitt-McQuitty (2015), California 4-H's educational programming is guided by environmental, social, and economic issues (e.g., water conservation, quality and security, alternative energy, food safety, and security). California 4-H has set-up their programming to work in partnership with community stakeholders in developing curriculum that is applicable to current STEM needs in local communities. Increasing scientific literacy can help advance economic prosperity, enhance environmental sustainability, develop energy technologies, and improve human health (Smith, Worker, Ambrose, & Schmitt-McQuitty, 2015).

Through numerous studies provided by the Cooperative Extension System it is evident that youth-adult partnerships and team learning are valuable teaching methods in STEM programs. In Oklahoma, 4-H uses an educational, service-based approach to encourage youth to explore scientific fields and careers through youth-adult teams. The Oklahoma 4-H STEM Institute promotes projects in: digital media, geospatial systems, Lego robotics, environmental conservation and forensics (Sallee & Peek, 2014*).* The Oklahoma 4-H STEM Institute found that the most successful STEM projects are youth-driven and adults-facilitated, with the use of local partners as mentors and funders (Sallee & Peek, 2014).

An example of National 4-H's Mission Mandate accomplishment is the *4-H Ag Innovators Experience*, which helped inspire and develop professional skills among young agriculturalists through a partnership with Monsanto Corporation and The Ohio State University. This opportunity allowed 8,000 youth across eight states to engage in a program entitled *Fish Farm Challenges* where they learned and developed new technologies to explore fish farming as an answer to food insecurities (Horton & House, 2015). This opportunity engaged teen leaders by training them to take the educational program back to their communities and facilitate the program throughout their state. As a result of their participation youth expressed their ability to think outside their comfort zone, display creativity, work in a team, explore career opportunities, and exercise communication skills (Horton & House, 2015).

Increasing the awareness of STEM in agriculture is one way that 4-H is meshing tradition with innovation. 4-H professionals in Ohio developed the *4-H* ChickQuest, where third grade teachers in thirty-six classrooms across the Akron school district implemented the chick incubation curriculum. The experience provided the teachers with more confidence in teaching the lifecycle to students and provided the students the opportunity to see the lifecycle happening within their classroom (Horton & Kreiger, 2013). This type of 4-H curriculum allowed urban youth the opportunity to see agriculture through the STEM lens by connecting concepts learned in class with hands-on experiences, taking student learning to a higher level of application.

Although there is success to be noted through formal and non-formal education venues related to STEM education, on a large scale, the lack of data and evidence portrays a grim outlook for the science field. As noted through literature there are entities in the United States (private and public) who are devoted to enhancing student interests in STEM fields, but the data has not been marketed to greater audiences. More measurement of outcomes of non-formal and formal education initiatives is needed in this area of study. While there is agreement that advancing scientific literacy among K-12 youth is important, measuring it has been problematic since there is no consensus about the meaning or component parts of scientific literacy (Smith, Worker, Ambrose, & Schmitt-McQuitty, 2015).

Formal educators face challenges in adopting and implementing STEM education within their classrooms. Those barriers include: adapting to new and evolving science standards, funding, professional development, integration across the curriculum, ensuring student involvement, linking concepts to career pathways, and providing out-of-school, experiences. Scientific and engineering occupations are expected to increase by seventy percent with 1.25 million additional jobs by 2012 (Nugent, Kunz, Rilett, & Jones, 2010). Although previous studies show that science and math are within the curriculum framework of many school systems, scientific literacy is low among American students and poor achievement in science in K-12 plague the United States education system (Worker, Ambrose, & Schmitt-McQuitty, 2015).

III. Methods

Purpose of Study

The purpose of this study is to identify if the Kentucky 4-H Program minimizes the barriers to access science, technology engineering and math programs for youth in grades 4-8. STEM programming has been offered within Kentucky 4-H since 2013, when the National 4-H Mission Mandates (Locklear, 2013) identified the need for more STEM programming in 4-H. Kentucky 4-H focuses curriculum on the following STEM areas: geospatial, bio-technology, robotics, aerospace, energy/electricity, petroleum power, and computer science. This study investigates which programs are being utilized across the Commonwealth to minimize barriers to STEM programs for all Kentucky youth.

Research Question

Does Kentucky 4-H minimize the barriers to engage youth in grades 4-8 in science, technology, engineering, and math programs?

Hypothesis

The Kentucky 4-H Program minimizes barriers to engaging youth in grades 4-8 in STEM education by providing opportunities to develop competences related to STEM through formal and non-formal education settings.

Framework

The framework of this study mirrors the ideal aspects of a well-rounded 4-H program. The intended educational framework of 4-H involvement should provide the opportunity for skill development within youth that can be applied throughout life. STEM Programs in Kentucky 4-H should contain evidence of the following framework: *Eight Essential Elements of Positive Youth Development*, *The Experiential Learning Model*, and *The Engineering Design Process.* Measuring outcomes based on these frameworks is ideal for this study to ensure STEM Programs are ultimately meeting the desire of well-rounded 4-H programs empowering youth to develop skills in 4-H core content areas, STEM being one of those areas.

4-H Youth Development professionals are encouraged to develop programming around the *Eight Essential Elements of Positive Youth Development* delivered through four key concepts. The purpose of these elements is to ensure a high standard of programming that will foster the positive development of youth across the nation who are involved in 4-H activities. Kress (2004) adapted the original work of Brendtro, Brokenleg, and Van Bockern (1990) by applying the *Circle of Courage* (belonging, independence, generosity, and mastery) to the work of 4-H Youth Development professionals. The elements adapted by Kress (2004) can be viewed in Figure 3. Youth learn best when they learn through experiences in an environment where they feel they belong, can exercise independence, have an opportunity to develop mastery of skills, and a chance to give back to their community. Positive youth development is the essence of 4-H (Kress & Sternweis, 2015). When youth learn by doing, they will lead by example (Kress & Sternweis, 2015). They will become the early adopter who will change their communities as a result of their access to education (Kress & Sternweis, 2015).

Eight Elements Distilled into Four Concepts	
Belonging 1) Positive Relationship with a caring adult 2) An inclusive environment 3) A safe environment	**Mastery** 4) Engagement in Learning 5) Opportunity for Mastery
Independence 6) Opportunity to see oneself as an active participant in the future 7) Opportunity for self-determination	**Generosity** 8) Opportunity to value and practice service

Figure 3: *Eight Elements Distilled into Four Concepts.* Adapted from: Kress, C. (2004) Essential Elements of 4-H Youth Development. National 4-H Headquarters, CSREES UDSA. (n.d.) Retrieved from www.national4-hheadquarters.gov/library/Essential_Element-Satellite.ppt

Non-formal education experiences youth encounter through involvement with 4-H are developed using *The Experiential Learning Model* (Diem, K., 2001). This model encourages critical thinking, group process, hands-on experiences, communicating results, and applying results to real-world concepts. *The Experiential Learning Model* can be applied to any content area, but is especially helpful in STEM programs. Through STEM education, rigorous academic concepts are coupled with real-world lessons as students apply STEM in context that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Slavit et. al, 2016). The recent STEM education literature provides rationale to teach STEM concepts in context, which is most often delivered in project, problem, and design-based approaches (Carlson & Sullivan, 1999; Kelley & Knowles, 2016). *The Experiential Learning Model* concept is described below in Figure 4.

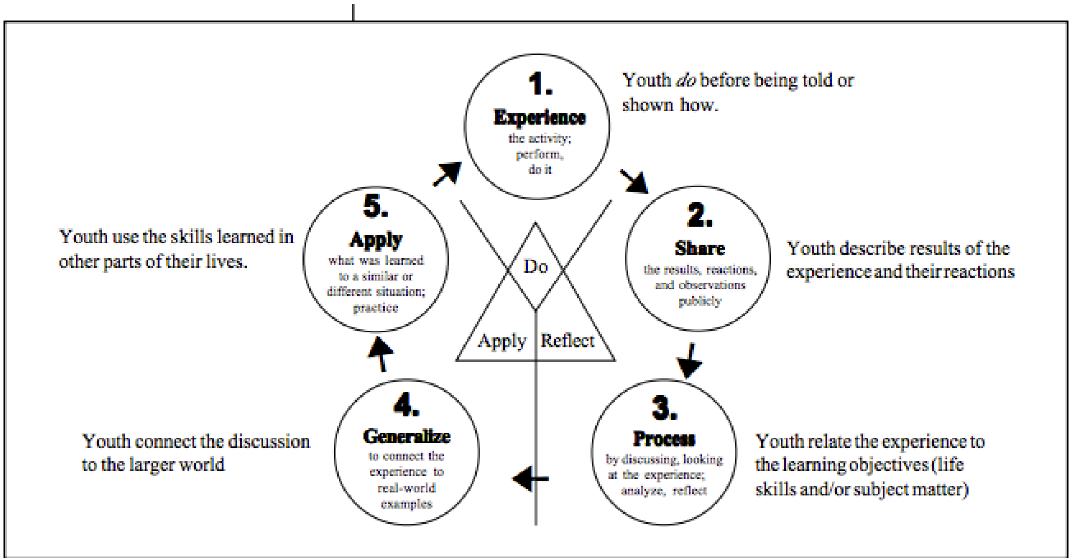


Figure 4: *The Experiential Learning Model. Source*: Diem, K. (2001). Learn by doing the 4-H way: Putting a slogan into practice. Rutgers Cooperative Extension Leader Training. 447-454.

The Engineering Design Process Poster provides framework that educators can use to explain the process behind STEM thinking in a language that makes sense to their students (Noble & Cassill, 2016). Youth have the opportunity to take ownership of their learning through critically thinking about what they are doing. *The Engineering Design Process Poster* is modeled from *The Experiential Learning Model* discussed previously and modified from the National 4-H Council's *Rockets to the Rescue* (2015) National Youth Science Day Project (National 4-H Council, 2015). *The Engineering Design Process: A Systematic Approach* was developed by Pahl, & Beitz, (1988, 1996) and redesigned by multiple researchers, including National 4-H. The visual in Appendix B was developed to enhance the 4-H science, technology, engineering, and math experiences for youth in 5th grade classrooms in Clark County, Kentucky.

Instrument Design

To answer the questions of this study a Likert-type questionnaire was developed through modifying the National 4-H Mission Mandates: Science Checklist (Locklear, 2013). The National 4-H Mission Mandates: Science Checklist was modified for this study to reflect the specifics of the Kentucky 4-H Program and the core areas identified by the state program, as well as to include the potential funding sources, delivery modes, and identified barriers to accessing STEM programming identified by existing research. Refer to Appendix C for a copy of the National 4-H Mission Mandates: Science Checklist.

A major contributor to the body of work of 4-H Positive Youth Development is Learner, Learner and Colleagues, which produced the 4-H Positive Youth Development study in 2002. The National 4-H Council and Tufts University have partnered since 2002 to evaluate the effectiveness of 4-H as a medium of positive youth development. 4-H STEM programs are proven to get kids excited about science by offering fun, hands-on activities, which builds confidence and fosters interest in STEM-related careers (Lerner, et al., 2013). This study is different than the 4-H Positive Youth Development Study related to design and timeframe; however, they are correlated by the educational framework: *Eight Essential Elements for Positive Youth Developmen,t* and *The Experiential Learning Process*.

Additionally, this study corresponds to the 4-H Science Initiative: Youth Engagement, Attitudes and Knowledge Study (YEAK Study) produced by Mielke and Butler (2013), which had goals to describe the characteristics and opinions of youth in 4-H science programs around the country and to illustrate the potential effects of 4-H science programs on youth. However, the study differs in the population surveyed. The YEAK Study surveys youth, whereas this study surveys adults involved in providing STEM programs for Kentucky youth through 4-H programs.

The study was developed using Qualtrics, a survey system which gives the researcher the ability to develop hundreds of different types of research questions (Qualtrics, 2017). The questionnaire was administered to Kentucky 4-H professionals. Approval for distributing the questionnaire was obtained from Dr. Mark Mains, Assistant Director of Kentucky 4-H Youth Development, and Dr. Jeff Young, Director of County Operations for the Kentucky Cooperative Extension Service. All data was kept confidential; the instrument had a qualifying question to participate, which validated participation.

Validity and Reliability of Instrument

The instrument was piloted for validity, reliability and usability by a test group in another Commonwealth. The test group was identified using the following criteria:

a. A state from the southern region who has similar demographics to Kentucky.
b. A state that was identified in the research as early adopters of the Next Generation Science Standards due to the focus on experiential science, technology, engineering and math educational opportunities.

Pilot Group Results

The Arkansas 4-H Program was selected to serve as the pilot group based on the criteria in the Research Methodology and Design section. The state of Arkansas was an early adopter of the Next Generation Science Standards and the Extension/4-H Youth Development system has similar characteristics as Kentucky Extension/4-H Youth Development. The pilot group data was collected as a test of the instrument's reliability, validity, and usability. Cronbach's Alpha was calculated for the pilot group data to test the validity and reliability of the instrument. The usability was determined by feedback from the pilot group participants.

The instrument was approved by Dr. Mark Mains, Assistant Director for Kentucky 4-H Youth Development, and sent to Arkansas 4-H Agents by Dr. Mains through the Interim Associate Department Head for Arkansas 4-H, Angie Blacklaw-Freel. The Arkansas 4-H Agents had one month to complete the study, thirty-three individuals responded to the survey. Cronbach's Alpha was .844, which is acceptable. Therefore, the instrument had reliable internal consistency. Table 1 reports the details of Cronbach's Alpha for the instrument with the pilot group data.

Table 1: Pilot Group Reliability Statistics

Pilot Group Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.844	.846	14

The pilot group provided feedback on the instrument related to usability. Based on the feedback the instrument was modified to ensure ease of use. The suggestions made by the pilot group and how the instrument was altered are listed below:

- Clarify the scale of ranking funding sources to support STEM programs.
    - There were several participants who listed that the ranking scale was confusing, therefore the question was changed to clarify the scale, “How are your STEM programs funded? Please rank, one being the most used funding source and seven being the least used funding source.”
- Include “hands-on” learning.
    - The suggestion to include hands-on learning was made, so in the experiential learning question “hands-on” was added. The question read, “Are activities led with an experiential approach to learning (hands-on)?”
- Limited options for topics of STEM programs provided.
    - The options were limited to just the core curriculum topics that are approved as focus areas by the Kentucky 4-H Program, therefore no changes were made.
- Define who volunteers can be.
    - List who a volunteer might be, “Are your learning experiences led by trained volunteers (volunteers in which you educate on the 4-H

Program and curriculum, can be teachers, parents, community members, etc.)?

- Define the engineering design process.
    - Included the steps to the engineering design process within the question. “Do you use the engineering design process? (identifying the problem, designing the solution, testing the solution)”
- The word “implement STEM programs” is awkward.
    - All instances of the word implement were changed to conduct.
- Survey was appropriate to the audience; questions considered diversity of experiences.

Data Collection

The final research instrument was administered to Kentucky 4-H professionals who conduct STEM 4-H programs for youth in grades 4-8. The goal of the study is to capture what 4-H is offering for in and/or out-of-school experiences related to STEM. There was only one accepted participant per county in Kentucky, therefore the available study population was 120. The goal was to have at least 60 participants. Refer to Appendix D for the Kentucky 4-H STEM Checklist cover letter and Appendix C for the Kentucky 4-H STEM Checklist.

The methodology and design chosen is appropriate for the research question because this type of research related to STEM programs has never been done in Kentucky 4-H. This type of research will prove valuable to enhance existing partnerships and potential partnerships between community stakeholders, industry, Kentucky public schools, and the Kentucky 4-H Program. Additionally, the data collected can be of use to expand programming to impact more youth across Kentucky.

Possible Types and Sources of Information or Data

This study was quantitative, surveying adult educators who administer 4-H Programs across Kentucky. One respondent per county was accepted. Respondents were Kentucky 4-H professionals providing STEM Programs for youth in grades 4-8, programs may be offered in or out-of-school. Programs may represent the Kentucky 4-H core curriculum areas: geospatial, bio-technology, robotics, aerospace, energy/electricity, petroleum power, and computer science. The cover letter and instrument are in the appendices section, Appendix B and Appendix C.

Analysis of Data

Data were analyzed by utilizing the Qualtrics reporting mechanism and SPSS. A one-way ANOVA was used to verify the findings across Cooperative Extension Districts to determine statistically significant differences in responses. Findings were analyzed against the barriers to STEM programs for youth identified within the literature and against the frameworks: *Eight Essential Elements of Positive Youth Development of Positive Youth Development, The Experiential Design Model,* and the *Engineering Design Process.*

IV. Findings

Participants

Seventy-five participants began the study. Nine participants answered "yes" to the qualifying question, "I am a Kentucky 4-H Youth Development Professional serving in a county role (4-H Agent, 4-H Program Assistant)," but did not answer any other questions. Therefore, those eight participants were eliminated from the study. Two participants answered "no" to the qualifying question that they were Kentucky 4-H Professionals, therefore they were eliminated from the study. The final study included sixty-five participants. The goal of the study was to obtain at least 60 responses; half of Kentucky's 120 counties. The response rate for the study was 53% (N=64).

The Kentucky Cooperative Extension Service is divided into seven districts across the Commonwealth (Appendix E). The district with the most participants was district 4, which includes the counties surrounding Lexington, Kentucky. The district with fewest participants was district 2, which includes Eastern Kentucky, the counties predominately in the Appalachian counties. There were eight participants who chose not to disclose their district, this did not impact the study's outcomes. Table 2 shows the breakdown of participants for the study and which district they work within. Appendix F shows the breakdown of the districts across Kentucky.

Table 2: Participants by Cooperative Extension District

Cooperative Extension District	Number of Participants
1	8
2	4
3	7
4	12
5	8
6	8
7	10
Did Not Report	8
Total	65

Topics Covered in STEM Programs

The most prominent STEM topic offered among the participants was energy/electricity programming, the least popular topic was petroleum power. 84.3% (n=54) of the participants reported that they offer energy/electricity programming. 67.18% (n=43) of the participants reported that they offer aerospace programming. 61% (n=39) participants reported that they offer robotics programming. 48.43% (n=31) of the participants reported that they offer bio-technology programming. 30% (n=19) of the participants reported that they offer computer science programming. 22% (n=14) of the participants reported that they offer geospatial programming. 14% (n=9) of the participants reported that they offer petroleum power programming. Figure 5 shows the breakdown of the various topics participants reported offering in STEM programming. The topics researched are Kentucky 4-H approved topics that 4-H Agents use in programming.

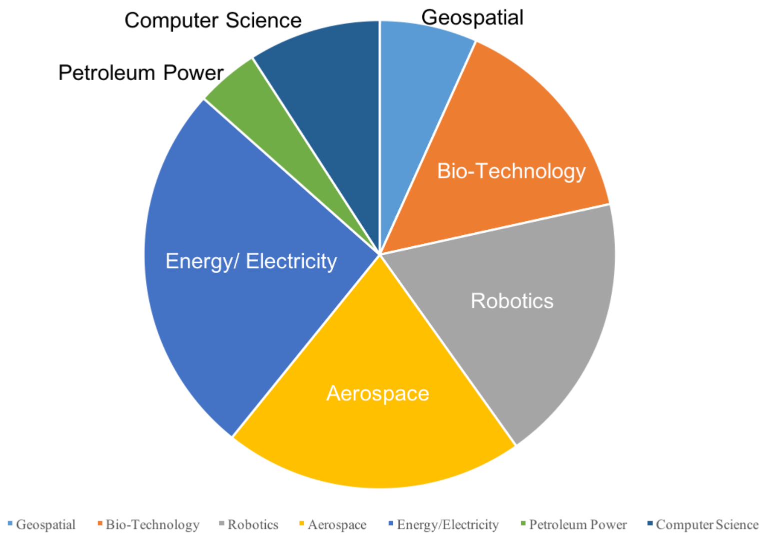


Figure 5: Topics Covered in STEM Programming

Grades STEM Programs Are Offered (In or Out-of-school)

The majority of participants reported they provide STEM programs to youth in the 4th grade, 95.3% (n=61) most frequently. Participants of the study reported they offer STEM programs to youth in the 8th grade less frequently, 62.5% (n=40). The overall projection of data shows a reverse linear regression from 4th grade to 8th grade of STEM programming. Figure 6 displays the breakdown of grades participants reported working with when conducting STEM programming.

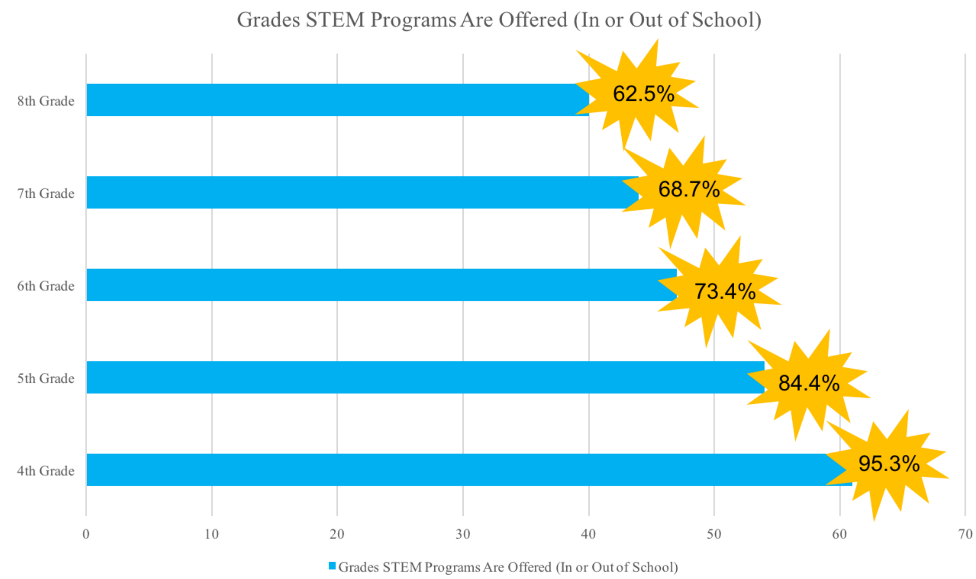


Figure 6: Grades STEM Programs are Offered (In or Out-of-school)

Learning Environment

Common delivery modes for programming in Kentucky 4-H include: after-school clubs, project clubs, community clubs, school enrichment, and SPIN (Special Interest) clubs. For details on the definition of each delivery mode refer to Appendix A. The most frequent learning environment participants reported conducting STEM programming was school enrichment, 50% (n=32). The least frequent learning environment was community club, which one participant reported (1.56%). Overall, 50% (n=32) of the participants also reported conducting STEM programming in the other delivery modes, which are outside of the formal education environment. Figure 7 shows the breakdown of learning environment participants work in when conducting STEM programs.

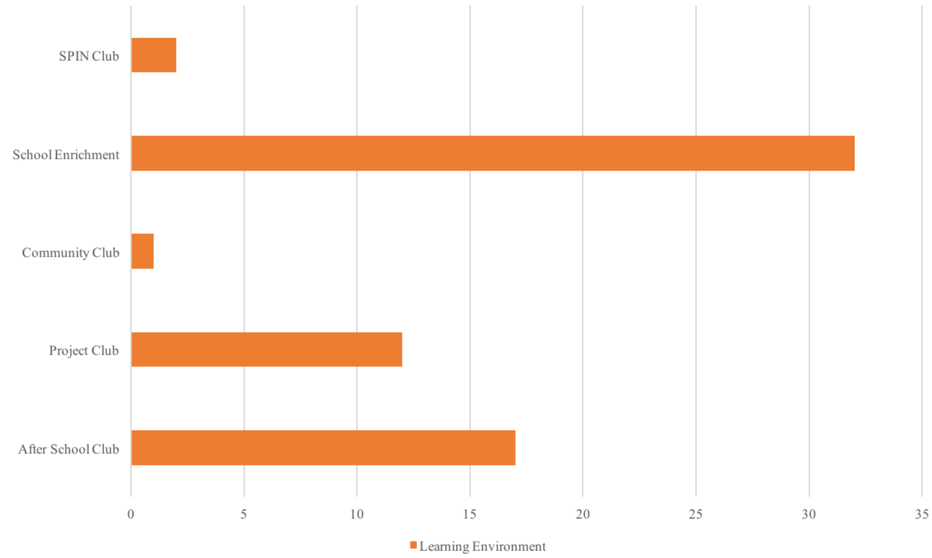


Figure 7: Learning Environment

Frequency of STEM Programming

The majority of participants reported that they conduct STEM programming when the need arises, 37.5% (n=24). The next most selected category was close, between every two weeks and once a week. 20.31% (n=13) reported offering STEM programs once a week, while 18.75% (n=12) reported every two weeks. 15.63% (n=10) reported that they offer STEM programs once a month. 6.25% (n=4) participants reported they offer STEM programs two times a week. The least often frequency was once a year with 1.56% (n=1). Figure 8 breaks down the participant’s answers by frequency of conducting STEM programming.

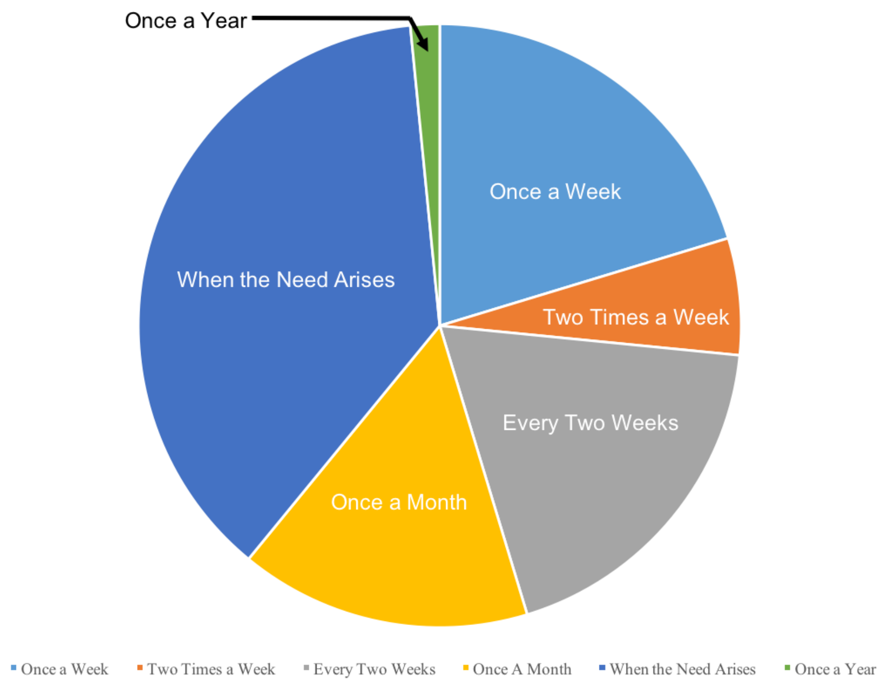


Figure 8: Frequency of STEM Programming

Timeframe for Conducting STEM Programming

The majority of participants reported having one hour to facilitate STEM programming, 49.10% (n=31). 26.98% (n=17) of the participants reported having 45 minutes. 14.29% (n=9) participants having more than two hours. 6.35% (n=4) of the participants reported having two hours. 3.17% (n=2) participants reported having 30 minutes. None of the participants reported having less than at least 30 minutes to conduct programming. Figure 9 shows the responses of the participants based on the amount of time they work with when conducting STEM programming.

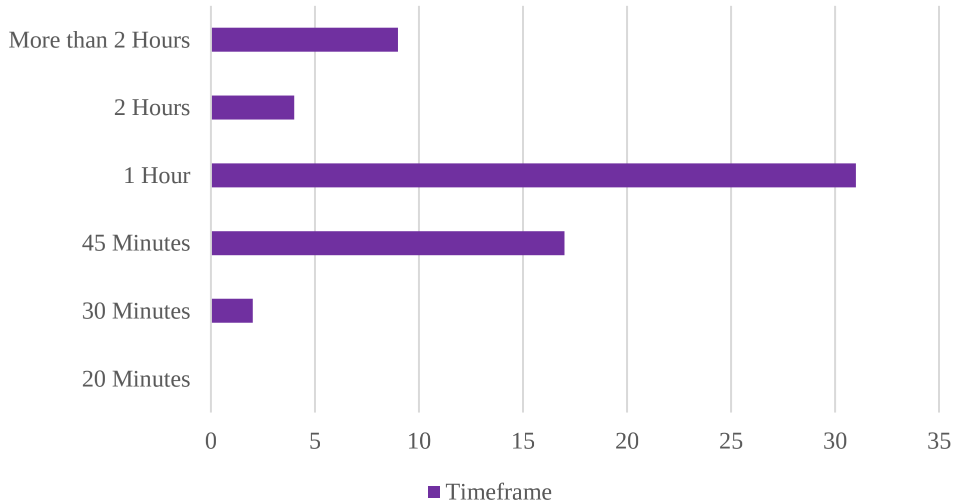


Figure 9: Timeframe for Conducting STEM Programming

Components of STEM Programming

A majority of the participants reported that they always or almost always use National Science Education Standards when implementing STEM programs, 65.6% (n=42). 79.68% (n=51) participants responded that they always or almost always use 4-H approved curriculum when conducting STEM programs. Participants reported that they always or almost always provide experience for youth to gain skills in the *Eight Essential Elements of Positive Youth Development* 81.2% (n=52). 71.43% (n=45) of participants reported that activities are always led with a hands-on approach to learning, 68.78% (n=44) report that youth are always or almost always given the opportunity to be partners and resources in their own learning, 65.08% (n=41) always foster curiosity and creativity, and 62.5% always or almost always use the engineering design process in STEM programs. Finally, 62.5% (n=40) reported that they always or almost always integrate multiple STEM concepts into programming.

The majority of learning experiences are led by 4-H professionals (48.39%; n=30) rather than volunteers (12.7%; n=8). 62.5% (n=40) of participants reported that Kentucky 4-H “always” or “almost always” provides quality training related to learning and implementing STEM programs for 4-H professionals and volunteers. The most popular setting for STEM programs between homeschool, private schools, and public schools was public schools with 36.51% (n=23) reported they always collaborate with public schools and 27.87% (n=17) reported they never collaborate with private school, and 22.22% (n=14) collaborating sometimes with homeschools. Table 3 shows the complete breakdown of participant responses related to components of STEM programming.

Table 3: Components of STEM Programming

Question	Always	Almost Always	Often	Sometimes	Almost Never	Never
Do you provide STEM programs based on National Science Education Standards?	26.56% 17	39.06% 25	14.06% 9	17.19% 11	3.13% 2	0.00% 0
Do you provide STEM programs based on 4-H curriculum and resources provided and approved through Kentucky 4-H?	40.63% 26	39.06% 25	9.38% 6	7.81% 5	3.13% 2	0.00% 0

Table 3: Continued

Question	Always	Almost Always	Often	Sometimes	Almost Never	Never
Do you provide opportunities for youth to experience and improve in the *Essential Elements* of Positive Youth Development through STEM programs?	40.63% 26	40.63% 26	9.38% 6	9.38% 6	0.00% 0	0.00% 0
Are your learning experiences led by trained volunteers (volunteers in which you educate on the 4-H Program and curriculum, can be teachers, parents, community members, etc.)?	12.70% 8	15.87% 10	28.57% 18	30.16% 19	6.35% 4	6.35% 4
If volunteers do not provide your learning experiences, are they led by 4-H Professionals?	48.39% 30	30.65% 19	12.90% 8	8.06% 5	0.00% 0	0.00% 0
Do you collaborate with public schools in your community to provide STEM programs?	36.51% 23	30.16% 19	20.63% 13	11.11% 7	1.59% 1	0.00% 0

Table 3: Continued

Question	Always	Almost Always	Often	Sometimes	Almost Never	Never
Do you collaborate with private schools in your community to provide STEM programs?	21.31% 13	11.48% 7	16.39% 10	14.75% 9	8.20% 5	27.87% 17
Do you collaborate with home school networks in your community to provide STEM programs?	12.70% 8	19.05% 12	17.46% 11	22.22% 14	15.87% 10	12.70% 8
Do you operate your programs from a perspective that youth are partners and resources in their own development?	35.48% 22	35.48% 22	9.68% 6	19.35% 12	0.00% 0	0.00% 0
Are activities led with an experiential approach to learning (hands-on)?	71.43% 45	23.81% 15	3.17% 2	1.59% 1	0.00% 0	0.00% 0
Are activities designed to foster the natural creativity and curiosity of youth?	65.08% 41	25.40% 16	7.94% 5	1.59% 1	0.00% 0	0.00% 0

Table 3: Continued

Question	Always	Almost Always	Often	Sometimes	Almost Never	Never
Do you feel Kentucky 4-H provides quality training related to learning and implementing STEM programs for 4-H Professionals and Volunteers?	23.81% 15	39.68% 25	23.81% 15	11.11% 7	1.59% 1	0.00% 0
Do you integrate multiple disciplines into STEM lessons?	26.98% 17	36.51% 23	23.81% 15	12.70% 8	0.00% 0	0.00% 0
Do you use the *Engineering Design Process*?	30.65% 19	33.87% 21	20.97% 13	14.52% 9	0.00% 0	0.00% 0

Funding Sources

The two outliers regarding funding sources for STEM programs were "program support monies" and "youth pay to participate." 72.13% (n=44) of the participants reported that their STEM programs are supported by "program support monies." The second most popular was "4-H Council" with 50% (n=32) reporting favorably. Youth pay to participate is the least often way that STEM programs are funded, 45.28% (n=24). Table 4 shows the breakdown of responses of participants by funding source.

Table 4: Funding Source Responses

Question	1 Most Often	2	3	4	5	6	7 Least Often
Grants	11.36% 5	27.27% 12	18.18% 8	11.36% 5	9.09% 4	15.91% 7	6.82% 3
Program Support Monies	72.13% 44	4.92% 3	4.92% 3	3.28% 2	1.64% 1	3.28% 2	9.84% 6
4-H Council	3.92% 2	35.29% 18	23.53% 12	13.73% 7	11.76% 6	5.88% 3	5.88% 3
School Funding	2.27% 1	11.36% 5	9.09% 4	18.18% 8	13.64% 6	27.27% 12	18.18% 8
Sponsorships	0.00% 0	6.82% 3	11.36% 5	27.27% 12	27.27% 12	22.73% 10	4.55% 2
Extension Personnel Personal Funds	4.00% 2	10.00% 5	20.00% 10	16.00% 8	16.00% 8	16.00% 8	18.00% 9
Youth Pay To Participate	7.55% 2	3.77% 2	7.55% 4	11.32% 6	13.21% 7	11.32% 6	45.28% 24

Minimizing the Barriers to STEM Education District Comparisons

The data were analyzed to compare Cooperative Extension Districts (districts) to one another based on providing programming to minimize the barriers to STEM education. The barriers to STEM education identified through existing research include: professional development, time, access to resources, funding, and out-of-school experiences. Each barrier category was analyzed using a one-way ANOVA test to determine if there were any significant differences in minimizing the barriers to STEM programs between districts. There were no statistically significant differences between the districts when the one-way ANOVA was conducted.

Professional Development

For the barrier of professional development, participants across all districts felt that Kentucky 4-H provided quality training related to learning and implementing STEM programs for professionals and volunteers. However, when a one- way ANOVA was conducted on the data set there was a statistically significant difference was found between districts 5 and 7, district 5 felt Kentucky 4-H provided training “often,” whereas district 7 felt training was “always” provided. The districts with the most favorable view of their training and education were the districts in the western part of the Commonwealth. Western Kentucky is where a full-time 4-H STEM Specialist is housed, focused on providing STEM curriculum and professional development to Kentucky 4-H professionals, volunteers, and youth.

Amount of Time to Conduct STEM Programming

When a one-way ANOVA was conducted with the data set to determine if there was a statistically significant difference between districts and the amount of time participants reported they were able to work with students when providing STEM lessons. An additional factor within the barrier of time is the frequency of implementing STEM programming. When districts were compared to determine if there was a difference in frequency of STEM programs, a statistically significant difference was not found.

Resources and Funding

For the purpose of this study, resources were measured through funding sources, trained volunteers and professionals who implement programming, and components of educational programming to meet student needs. Additionally, observing if 4-H professionals are providing programming to national STEM standards, utilizing 4-H resources/curriculum in programming, providing an opportunity for youth to develop in the *Eight Essential Elements of Positive Youth Development*, implementing the *Engineering Design Process,* and *The Experiential Learning Model*. The funding options analyzed in the study included: grants, program support monies, 4-H council, school funding, sponsorships, personal funds, and youth pay to participate.

A statistically significant difference was not found between any of the districts, in the category of funding. Educational resources examined in the study: use of the engineering design process, hands-on learning opportunities through the experiential learning approach, "operation of programs from a perspective that youth are partners and resources in their development," 4-H curriculum, and national sciences standards. The only area in the above factors that showed a statistically significant difference among districts was, "operation of programs from a perspective that youth are partners and resources in their development," which had a significance level of $p=.023$, which is less than 0.05. Upon further investigation the two districts that had a statistically significant difference were districts 1 and 3. Participants in district 1 reported that they "almost always" to "often" operate their programs from a perspective that youth are partners and resources in their development whereas, district 3 reported they always operate their programs in this manner.

Finally, the use of trained professionals and volunteers to implement STEM programming was examined among districts and a statistically significant difference was not found in either category among districts. However, the least frequent answer was that districts are utilizing volunteers in implementation of STEM programming. The majority of STEM programming across the Commonwealth are being offered by 4-H professionals.

Integration Across the Curriculum

The next barrier to STEM education examined among districts was integration across the curriculum. The category in the study that measured integration was, "integration of multiple topics within lessons." There was not a statistically significant difference among the districts within the responses of this question. The majority of respondents reported that they are integrating multiple topics within STEM lessons.

Out-of-school Experiences and Audiences

The out-of-school experiences category was measured by the delivery mode in which STEM programs are offered, and collaboration with public schools, private schools, and homeschool networks. A statistically significant difference in the environment STEM programming is offered between the districts was not found. The most frequent answer across the districts was that participants provided STEM programming through school enrichment. A statistically significant difference among the collaboration between public schools, private schools, and homeschools was not found. The majority of participants collaborated with public schools.

The majority of participants also provided STEM programs for youth in 4th grade, however programming was offered through all grades (4-8). Although school enrichment was the most frequent environment in which participants provided STEM programs, it is important to note that half of the participants are also providing some type of STEM programming out-of-school.

Perceived Barriers

This study represents over half of the Kentucky 4-H program, N=64 professionals participated representing their county. There were 120 participants possible, since there are 120 counties in Kentucky. One of the qualifying questions asked, “I provide 4-H science, technology, engineering, and math (STEM) programs for youth in my county.” 100% of the participants provided STEM programming. Therefore, the participants did not report any perceived barriers to providing STEM programming through Kentucky 4-H for youth in grades 4-8. Relating directly to the hypothesis of this study.

V. Discussions

Summary

The hypothesis of this study was that the Kentucky 4-H Program minimizes barriers to science, technology, engineering, and math education (STEM) by providing opportunities for youth in grades 4-8 to actively engage in programming to develop competences related to STEM through formal and non-formal education settings. The study had a 53% response rate, equaling 64 participants from 120 of the Kentucky 4-H programs participated in the study. Participants from each of the seven Kentucky Cooperative Extension Districts were involved. Kentucky 4-H is utilizing the foundational framework of positive youth development (*Eight Essential Elements of Positive Youth Development*, *Experiential Learning Model*, and *Engineering Design Process)* along with national and 4-H curriculum to provide opportunities for youth in grades 4-8 to build competencies in STEM.

The majority of Kentucky 4-H professionals are providing some type of STEM programming through various delivery modes for youth in grades 4-8. The most frequent delivery mode was school enrichment, through formal education. The most frequent time spent with youth providing STEM programs was one hour, when the need arises. The most common topic covered in STEM programs, reported by the participants, is energy/electricity, followed by aerospace, robotics, bio-technology, computer science, geospatial, and petroleum power. There was a steady decline in providing STEM programming for youth in older grades, the most frequent grade the participants reported working with was 4^{th} graders, then 5^{th}, 6^{th}, 7^{th}, and finally 8^{th}.

Providing STEM programming can be costly to program participants, schools, and organizations. Counties reported that the least frequent way Kentucky 4-H funds STEM programming is having the youth participants pay. The majority reported that Extension program support monies are always used when providing programming, followed by 4-H Council monies. This minimizes the funding barrier to participate in STEM programs and allows all youth to participate.

The majority of Kentucky 4-H STEM programs follow national science curriculum, as well as 4-H curriculum. *The Engineering Design Process* is utilized for youth to have the opportunity to express their “creativity and curiosity” through interdisciplinary STEM lessons. Kentucky 4-H allows youth to be “active participants in their own learning experience” through *The Experiential Learning Model* developing critical thinking skills. Kentucky youth have the opportunity to develop within the *Eight Essential Elements of Positive Youth Development* in Kentucky 4-H STEM programs: mastery, belonging, independence, and generosity. It is viewed that Kentucky 4-H has a network of volunteers and professionals who receive quality training related to learning and implementing STEM programs.

Conclusions

Through the results of this study it can be determined that Kentucky 4-H is minimizing the barriers for youth in grades 4-8 to access STEM education.

Especially since none of the respondents reported barriers to providing STEM programs in their county. Professionals in the field are utilizing national science standards, as well as national 4-H standards, to ensure youth have the opportunity to develop competencies related to STEM. Overall, the study was consistent in showing that Kentucky 4-H is conducting STEM programs with a solid foundational design.

Not only do 4-H professionals plan programs to standards, opportunities that engage youth in their own learning are implemented too. *The Engineering Design Process*, which empowers the learner to critically think through the learning process, is utilized in Kentucky 4-H STEM programs across the Commonwealth. The study showed that learners have the opportunity to experience and improve in the *Eight Essential Elements of Positive Youth Development*, which focus on belonging, independence, mastery, and generosity. This type of learning environment leads youth toward developing life skills that can be taken into later stages of life.

Existing literature also suggests that to develop competencies in STEM, youth must be exposed to STEM experiences at a young age (DiLisi, McMillin, & Virostek, 2011; DeJarnette, 2012). The most frequent population receiving STEM programming through Kentucky 4-H are 4^{th} and 5^{th} graders, the youngest audience option within the study. Full participation in 4-H begins at the age of 9 and a national trend of involvement that is evident in Kentucky 4-H’s numbers show the decline of participation starting in middle school through high school (Kentucky 4-H, 2017). This does not mean that opportunities are not available, but rather, the programs that are offered are more attractive to younger youth or the younger audience is more willing to participate. This trend is, and will continue to be, an area of weakness. The weakness is apparent in the general Kentucky 4-H enrollment, not just in STEM programming. Figure 10 shows the comparison of involvement in STEM programming by grade and enrollment of Kentucky 4-H members by grade from the federal ES237 report (Kentucky 4-H, 2017).

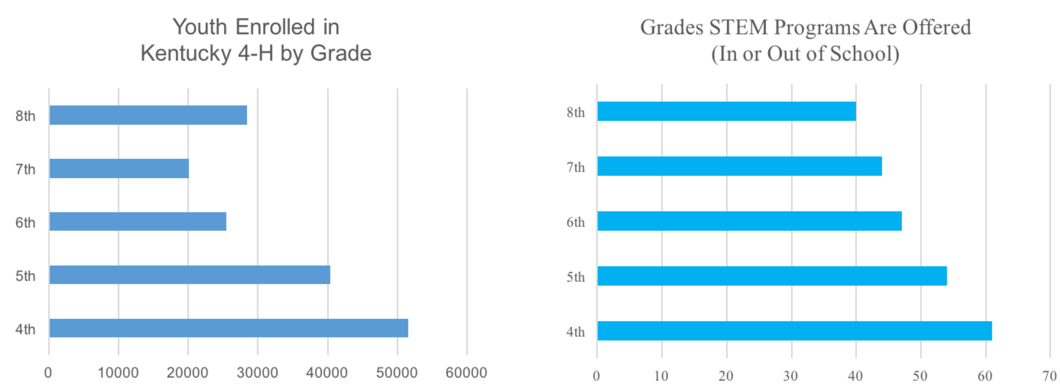


Figure 10: Youth Enrolled in Kentucky 4-H Compared to Grade STEM Programs Are Offered Adapted: Kentucky 4-H. (2017). ES237: Federal reporting.

Additionally, literature suggests that youth need to be exposed to mentors in their field of interest to develop a sense of belonging (Sallee & Peek, 2014). Kentucky 4-H is attempting to provide opportunities for youth to connect with volunteers as the study suggests, but the majority of county's 4-H professionals lead programming rather than volunteers. This allows for room for improvement in recruiting volunteers with STEM expertise or passion. This finding provides an opportunity for sponsorships and collaborations between companies and 4-H programs, potentially expanding program offerings and the chance for mentorships between youth and adults.

One area of inconsistency found in the study, related to the literature, is that out-of-school opportunities should be provided for youth to gain competencies in STEM. The county 4-H professionals who participated in the study reported that the most prominent delivery mode (learning environment) is within a formal school setting (school enrichment). This allows for an area of improvement for Kentucky 4-H, preparing and implementing programming for out-of-school time within the project club or community club setting. This finding does not mean that out-of-school opportunities are not provided, but rather, not provided as often as during school. 50% (n=32) of the respondents reported that they provide some type of out-of-school STEM opportunities. This is an important observation, but the out-of-school opportunities should be more frequent. Kentucky 4-H is providing STEM opportunities through formal and non-formal education settings.

An alarming finding was that STEM programs were mostly offered "when the need arises" and for "1 hour." Through Kentucky 4-H standards, a well-rounded experience where youth engage in a higher level of learning provides six hours of education (Kentucky 4-H, 2013). This finding does not support that Kentucky 4-H professionals are providing enough time to develop a higher level of STEM competencies; merely providing exposure to STEM topics. This area of improvement for the Kentucky 4-H program could lead to more positive long-term impacts of STEM programs for youth involved.

Based on the findings of the study 4-H professionals in the Cooperative Extension Districts located in the center of the Commonwealth, where the majority of the population is located and the majority of state universities are housed (Community & Economic Development Initiative of Kentucky, 2017) reported less favorable opinions about the professional development training and education received by Kentucky 4-H to provide STEM programs. An assumption of this finding would be that since this area of the Commonwealth is the area with the most growth (Kentucky State Data Center, 2017) technology is evolving at a quicker pace, these professionals may believe training cannot be produced quick enough to prepare them to provide programming based on the changing topics and societal demands of STEM. The areas that viewed training and education most favorably are the peripheral Cooperative Extension Districts. The most favorable view of training and education provided was western Kentucky, a Kentucky 4-H STEM Specialist is based out of the University of Kentucky's Paducah campus.

Limitations

Limitations for this study were attempted to be minimalized during development. However, as with study, some limitations are beyond control of the researcher. One limitation that might have impacted the involvement of 4-H professionals in the study is the fear of being identified, then receiving repercussions for not providing STEM programming. Additionally, the study could have been limited by the understanding and frame of mind of the individuals receiving the questionnaire. STEM can be a daunting field of study, therefore if a professional felt less comfortable with the topic they may have ignored the request for participation. Finally, the available population for the study was limited due to the number of counties in the Commonwealth of

Kentucky. Finally, the manner in which the study was set-up could have inhibited individual participation. If the respondent answered that they provided STEM programs they did not answer what they perceived as barriers to providing STEM programming, therefore the study may have missed participants.

Recommendations for Future Research

Future investigation is needed to study how youth's involvement in Kentucky 4-H STEM programs influence their decision to major in a STEM related field in post-secondary education. Likewise, if involvement in 4-H STEM programs influenced their decision to enter a STEM career or job. Related to the specific STEM topics, it might be of benefit to Kentucky 4-H to examine how STEM programs are selected to be provided, is it by the 4-H professional's interest or societal demands? Does Kentucky 4-H take into consideration state standards when choosing topics for STEM education? Additionally, keep the instrument that same, but change the population of the participants to youth observing their perspective of Kentucky 4-H STEM programs. Volunteers are a major aspect of Kentucky 4-H programs; therefore, the use of volunteers should be investigated. Do the programs led by volunteers offer a higher level of programming related to STEM competencies or are they more attractive to youth? Finally, related to perceived barriers to STEM education. Since none of the participants reported barriers, further research can be done to determine why the other 56 counties did not participate in the study and if they perceive barriers to STEM education in their county.

Recommendations for Kentucky 4-H

There are areas of advancement that Kentucky 4-H can act upon to continue minimizing barriers to STEM education for youth, which have been identified through this study. Kentucky 4-H should identify ways to provide more out-of-school time opportunities within county programs for youth to advance in STEM competencies, utilizing the community club or project club model. Kentucky 4-H should work to collaborate with more volunteers within county programs to offer STEM programming, allowing opportunities for mentorship for youth and future sponsorships and collaborations within the community. Kentucky 4-H should focus on offering STEM programming to youth at all levels, specifically as they enter middle and high school. The timeframe for conducting STEM programming should be utilized and professionals should move toward offering longer periods of education opportunities so youth may develop a deeper level of understand of STEM topics. Finally, Kentucky 4-H should analyze the STEM topics offered and ensure they are meeting societal demands, as well as workforce needs within the state, nationally, and globally.

Significance

This study is meaningful to the body of knowledge for positive youth development and Kentucky 4-H in multiple ways. The first, Kentucky 4-H has never attempted this type of study, investigating what types of STEM programming 4-H professionals are conducting throughout the Commonwealth and if those efforts are minimizing the barriers to access STEM programs for youth. The second, STEM education is a trending topic throughout the education profession (formal and non-formal) as our demand for a STEM-minded workforce increases. Through identifying areas of strengths for Kentucky 4-H related to STEM programs, 4-H professionals may be able to target areas of weaknesses and enhance educational experiences through focused programming.

Nationally, 4-H professionals develop and implement programming utilizing the *Eight Essential Elements of Positive Youth Development*, *The Experiential Learning Model*, and *The Engineering Design Process* (specifically for STEM programming). The goal of any 4-H program, regardless of subject area, is to ensure youth have the opportunity to belong to a group, develop independence, practice generosity, and gain confidence through mastery (*Eight Essential Elements of Positive Youth Development*, Brendtro, Brokenleg, and Van Bockern, 1990; Kress, 2004). The study identified that 4-H professionals are providing youth the opportunity to advance within the *Eight Essential Elements of Positive Youth Development* within Kentucky 4-H STEM programming, which is valuable to their long-term development as learners and contributors of their community. The study also shows that 4-H professionals are encouraging youth to creatively and critically think through *The Engineering Design Process* and *The Experiential Learning Model*. Through implementing the discussed framework models, Kentucky 4-H youth development professionals are aiding youth in the development in key areas that advance them into the future. The hypothesis of this research is accepted and the research questions answered. The Kentucky 4-H Program minimizes barriers to engaging youth in grades 4-8 in STEM education by providing opportunities to develop competences related to STEM through formal and non-formal education settings.

References

APLC (Association of Public and Land-Grant Universities). (2009). *The land-grant tradition*. Washington, DC. Retrieved from: http://www.aplu.org/document.doc?id_780

Barker, B.S., Larson, K., & Krehbiel, M. (2014). Bridging formal and informal learning environments. *Journal of Extension*, 52(5).

Brendtro, L., Brokenleg, M., Van Bockern, S., & Tutu, A.D. (2009). *Reclaiming youth at risk: Our hope for the future.* Bloomington, Indiana: Solution Tree. (Original work published 1990).

Community & Economic Development Initiative of Kentucky. (2017). Retrieved from https://cedik.ca.uky.edu/data_profiles/education

Conglose, J.B. (2000). The Cooperative Extension Services' role in running a successful county economic development program. Journal of Extension, 38(3) Article 3FEA3. Retrieved from: http://www.joe.org/joe/2000june/a3.php

DeJarnette, N. (2012). America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives. Education. 133(1), 77-84.

Diem, K. (2001). Learn by doing the 4-H way: Putting a slogan into practice. Rutgers Cooperative Extension Leader Training. 447-454.

DiLisi, G., McMillin, K., & Virostek, M. (2011). Project WISE: Building STEM-focused youth-programs that serve the community. *International Journal of STEM Education*, 12(5&6), 38-45.

Ejiwal, J. (2013). Barriers to successful implementation of STEM education. *Journal of Education and Learning*. 7(2), 63-74.

Hendricks, P.A. *Developing Youth Curriculum Using the Targeting Life Skills Model: Incorporating Developmentally Appropriate Learning Opportunities to Assess Impact of Life Skill Development* (Iowa State Extension Publication 4H-137A, 1998). Ames, IA: Iowa State University.

Heil, D. R., Pearson, G., & Burger, S.E. (2013) Understanding integrated STEM education: Report on a national study. *American Society of Engineering Education*. #7712.

Hoachlander, G., & Yanofsky, D. (2011). Making STEM real. *Educational Leadership*, 60-65.

Horton, R.L., & House, P. L. (2015). Fish farm challenge provides STEM design experiences for youth. *Journal of Extension*, 53(4).

Horton, R.L., Kriegar, J., & Halasa, K. (2013). 4-H chickquest: Connecting agri-science with STEM standards in urban schools. *Journal of Extension*, 51(1).

Kelley, T. & Knowles, J.G. (2016) A conceptual framework for integrated STEM education. *International Journal of STEM Education*. 3:11, 10.1186/s40594-016-0046-z.

Kennedy. T. & Odell, M. (2014). Engaging students in STEM education. *Science Education International*, 25(3), 246-258.

Kentucky 4-H. (2013). Federal definitions of delivery modes adapted for Kentucky use in ACCESS. Retrieved from https://4-h.ca.uky.edu/sites/4-h.ca.uky.edu/files/james_new_web/16_Delivery_Method_Definitions_for_ES237_for_use_in_KY_beginning_2-14-2013_landscape%20%282%29.pdf

Kentucky 4-H (2016). Making a difference, to make the best better. University of Kentucky. 1-2. Retrieved from: http://4-h.ca.uky.edu/sites/4-h.ca.uky.edu/files/kentucky_handout_2016_final2.pdf

Kentucky 4-H. (2017). ES237: Federal reporting.

Kentucky 4-H. (2017) Who can join 4-H? Retrieved from https://4-h.ca.uky.edu/content/who-can-join-4-h

Kentucky State Data Center. (2017). Retrieved from http://www.ksdc.louisville.edu//wp-content/uploads/2015/05/bgadd.pdf

Kolb, D.A. (1984). The process of experiential learning. *Experiential learning: experience as the source of learning and development.* Retrieved from http://academic.regis.edu/ed205/kolb.pdf

Kress, C. (2004) Essential Elements of 4-H Youth Development. National 4-H Headquarters, CSREES UDSA. (n.d.) Retrieved from www.national4-hheadquarters.gov/library/Essential_Element-Satellite.ppt

Kress, C. (2014). Transformation education: The 4-H legacy. *Reclaiming Children and Youth,* 23(3), 5-9.

Kress, C. & Sternweis, L. (2015). Cathann Kress receives 2015 spirit of crazy horse award. Retrieved from: http://www.extension.iastate.edu/article/cathann-kress-receives-2015-spirit-crazy-horse-award

The Heritage Foundation. (n.d). (2016, November 24). Retrieved from http://www.heritage.org/research/reports/2011/01/educate-to-innovate-how-the-obama-plan-for-stem-education-falls-short

LaForce, M., Noble, E., King, H., Century, J., Blackwell, C., Holt, S., Ibrahi, A., & Loo, S. (2016). The eight essential elements of inclusive STEM high schools. *International Journal of STEM Education*. 3:21. DOI 10.1186/s40594-016-0054-z.

Lerner, R.M., Lerner, J.V., Almerigi, J., Theokas, C., Phelps, E., Gestsdottir, S., Naudeau, S., Jelicic, H., Alerts, A., Ma, L., Smith, L., Bobek, D., Richman-Raphael, D., Simpson, I., Christiansen, E. D., & von Eye, A. (2013). 4-H study of positive youth development. National 4-H Council.

Lerner, R.M., & Lerner, J.V. (2012). The 4-h study of positive youth development. 2012 summary of findings from wave 8. Retrieved December 16, 2017 from http://www.4-h.org.about/youth-developmebt-research/positive-youth-development-study/

Locklear, E.L. (2013). 4-H science initiative from inception to impact: Methodologies, lessons learned, best practice and recommendation. (2016, December 10). Retrieved from http://www.4-h.org/youthstem/

Martz, J., Mincemoyer, C., McNeely, N., Blesoe, L., Dart, P., Johannes, E., Arnould, A., Gressley, K., Jones, K., Lerner, J., McDonald, D. & Worthington, K. (2016). Essential elements of 4-H youth development training and curriculum guide. National 4-H Council.

Mielke, M. & Butler, A. (2013). 4-H science initiative: Youth engagement, attitudes, and knowledge study. Policy Studies Associates, Inc. National 4-H Council.

Morgan, E., K. Sargianis, R. Skophammer, C. Cunningham, N. Yocom de Romero, & K. Murphy-Garcia. (2012). Engaging elementary students. *Children's Technology and Engineering*, 8-12.

Moye, J.J., Dugger, W.E., & Stark-Weather, K.N. (2015). Learning by doing study: Analysis of second-year results. *Technology and Engineering Teacher*, 18-25.

Moye, J.J., Dugger, W.E., & Stark-Weather, K.N. (2012). The status of technology and engineering education in the United States: A fourth report of the findings from states (2011-12). *Technology and Engineering Teacher*, 25-31.

Nadelson, L., Seifert, A., Moll, A., & Coats, B. (2012). i-STEM summer institute: An integrated approach to teacher professional development in STEM. *International Journal of STEM Education.* 13(2), 69-83.

National 4-H Council. (2015). Rockets to the Rescue. Retrieved from https://4-h.org/wp-content/uploads/2016/03/4-H-NYSD-Rockets-to-the-Rescue-Facilitator-Guide-Color.pdf

Next Generation Science Standards Adoption Map - Academic Benchmarks. (2013) Retrieved from http://academicbenchmarks.com/next-generation-science-standards-adoption-map/

Noble, R. & Cassill, H. (2016). Engineering design process.

Nugent, G., Kunz, G., Rilett, L., & Jones, E. (2010). Extending engineering education to k-12. *The Technology Teacher*, 14-19.

Occupational Outlook Quarterly. (2014). Stem 101: Intro to tomorrow's jobs. (2017, February 28). Retrieved from https://www.bls.gov/careeroutlook/2014/spring/art01.pdf

Pahl, G. & Beitz, W. (1988, 1996). *Engineering Design: A systematic approach*. London, England: Springer-Verlag London.

President Obama Expands "Educate to Innovate" Campaign for Excellence in Science, Technology, Engineering, and Mathematics (STEM) Education. (n.d). (2016, November 24). Retrieved from https://www.whitehouse.gov/the-press-office/president-obama-expands-educate-innovate-campaign-excellence-science-technology-eng

Qualtrics. (n.d.) (2017, February 28) Retrieved from https://www.uky.edu/its/atg/qualtrics

Russell, S.T. (2001). The development benefits of nonformal education and youth development. The University of California-Davis. Summer 2001.

Sallee, J. & Peek, G.G. (2014). Fitting the framework: The STEM institute and the 4-H essential elements. *Journal of Extension*, 52(2).

Schroeder, K., Woodland, J., Lang, C., Barker, B., Mulkerrin, E., Novotny, J., Williams, G., Krishnamurthi, A., Noam, G., & Ottinger, R. (2013). STEM & out-of-school time. Retrieved from http://netnebraska.org/basic-page/learning-services/out-school-time-and-stem.

Science and Engineering Indicators. (2014). (2016, November 24). Retrieved from http://www.nsf.gov/statistics/seind14/index.cfm/chapter-3

Shernoff, D., Sinha, S., Bressler, D., & Ginsburg, L. (2017). Assessing teacher education professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education*. 4:13. DOI 10.1186/s40594-017-0068-1.

Slavit, D., Holmlund, N., & Lesseig, K. (2016) The teachers' role in developing, opening, and nurturing an inclusive STEM-focused school. *International Journal of STEM Education*. 3:17. DOI 10.1186/s40594-016-0040-5.

Smith, M. H., Worker, S. M., Ambrose, A. P., & Schmitt-Mcquitty, L. (2015). Scientific literacy: California 4-H defines it from citizens' perspective. *Cal Ag California Agriculture*, *69*(2), 92–97. http://doi.org/10.3733/ca.v069n02p92

Topical Arrangements of Standards | Next Generation Science Standards. (n.d.) (2016, November 24). Retrieved from http://www.negxtgenscience.org/search-standards

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM education: A project to identify the mission components*, Intermediate Unit 1 and Carnegie Mellon, Pennsylvania.

Top Ways to Attract Youth to STEM. (n.d.) (2017, March 22). Retrieved from http://4-h.org/about/research/#!science.

University of Kentucky: College of Agriculture, Food, and Environment. (2017). *Counties and Districts*. Retrieved from http://extension.ca.uky.edu/county

Van Horn, B. E., Flanagan, C.A., & Thomson, J.S. (1998). The first fifty years of the 4-H program (part 1). *Journal of Extension*, 36(3).

Walker, J. (1998). Youth development education: Supports and opportunities for young people. *The Center.* University of Minnesota Center for 4-H Youth Development. Winter:10-13.

Walker, J & Dunham, T. (1996). Understanding youth development work. Minneapolis, MN: Minnesota Extension Service. Retrieved from: http://www.extension.umn.edu/youth/training-events/understanding-youth-development-work/

Worker, S., & Mahacek, R. (2013). 4-H out-of-school-time STEM education. *Children's Technology and Engineering*, 16-20.

APPENDIXES

Appendix A

Federal Definitions of Delivery Modes Adapted for Kentucky 4-H Use in ACCESS

Federal Definitions of Delivery Modes Adapted for Kentucky 4-H Use in ACCESS

Federal Definitions of Delivery Modes Adapted for Kentucky Use in ACCESS

Effective: 2-2013

Organized 4-H Clubs: A 4-H Club is an organized group of youth that elects officers, is led by an adult, completes at least 6 hours of instruction during a series of planned educational experiences, and meets multiple times over the course of a few months to throughout the year. Clubs are reported in the following categories:

- ***Community clubs*** typically meet in the evenings or on weekends and offer self-chosen multiple learning experiences and activities.
- ***In-school clubs*** meet during school hours, but have officers and planned activities beyond school enrichment.
- ***4-H after-school* care clubs** are organized within settings which provide child care after school. Child care may be administered by CES staff or other organizations such as the school system, housing authority, faith-based groups, or other youth development organizations. They meet the above definition of a 4-H Club and the young people and adults identify themselves as 4-H members and volunteers.
- ***Military 4-H clubs*** are organized by the Armed Forces, often on military installations, and principally for military dependents.

Note: **SPIN Clubs** (special interest clubs) should be placed in the club category above that is most similar to the way the club operates.

Special-Interest and Short-Term Programs: Groups of youth meeting for a specific learning experience that involves direct teaching by Extension staff or Extension trained volunteers (including teachers). Program is NOT part of the school curriculum. Multiple-day educational experiences, such as conferences or seminars, may be reported here. Groups should complete at least 6 hours of instruction.

Overnight Camping Programs: Youth taking part in an Extension-planned educational experience of group living in the out-of-doors. Overnight camping includes being away from home at least one night (resident, primitive, or travel camping). (Example: Summer camp held at a KY 4-H camp should be included here.)

Day Camping Programs: Youth taking part in an Extension-planned educational experience of a group meeting in the out-of-doors. Day camping consists of multiple-day programs, with youth returning home each evening. ("Day camps" in which youth are not meeting in the out-of-doors should be counted as Special-Interest/Short-Term Programs.)

School Enrichment Programs: Groups of youth receiving a sequence of learning experiences which support the school curriculum in cooperation with school officials and held during school hours. It involves direct teaching by Extension staff or trained volunteers (including teachers).

Individual Learning/Mentoring/Family Learning Programs: Planned learning that occurs independently of a formal group. Learning is usually self-directed with limited adult involvement except for parents or a mentor. Examples: self-study, mentoring or shadowing with an "expert," whole families learning together.

After School Programs Using 4-H Curricula/Staff Training: 4-H programming offered to youth outside of school hours in after-school child care settings such as those operated by the school system, housing authority, faith-based groups or other youth development organizations. The primary purpose of the program is to provide care, developmental and educational experiences for youth while parents are working or unavailable. 4-H programming may be provided by Extension staff or volunteers/child care workers who have been trained by Extension. The programming must be supported by Extension by infusing 4-H curricula into the program and/or other significant support such as conducting needs assessments, evaluations, and/or resource development. The youth in these programs should be enrolled as 4-H members in the county program, have the benefits of all 4-H programs and activities, and identify themselves as 4-H members. (4-H **clubs** in after-school settings should be reported under Organized 4-H After-School Clubs.) (As general guidance, the child care facility should operate approximately 3 days per week/two hours per day for about five months of the school year or three days per week/six hours per day throughout the summer.)

Instructional TV/Video/Web Programs: Youth offered learning experiences through Extension via broadcast or closed circuit television (including satellite transmission) or videotape replays of such series. May also include instruction delivered by internet.

C:\Users\jale227\Desktop\4HOnline Training Docs\16_Delivery_Method_Definitions_for_ES237_for_use_in_KY_beginning_2-14-2013_landscape (2).docx

(Kentucky 4-H, 2013)

Appendix B

Engineering Design Process Poster

Engineering Design Process Poster

COOPERATIVE EXTENSION

University of Kentucky
College of Agriculture, Food and Environment

Engineering Design Process

1. Identify the Problem

Comprehend: What's going on?

Identify: What are they asking us?

Constraints: How will our design be limited?

2. Design your Solution

Brainstorm: What are our ideas to solve the problem?

Design: What can we design and build based on our constraints?

Build: Who will take what responsibilities?

3. Test your Design

Test: Are we ready to test our design?

Record: What are our findings?

Improve: How can we improve our design?

Retest: Are we ready to retest our design?

Record: What are our findings?

Visual Created by: Rachel E. Noble and Heather Cassill, Clark County 4-H

Appendix C

The National 4-H Science Checklist

The National 4-H Science Checklist

4-H Science Checklist Questions

- ☐ Are you providing science, engineering and technology programs based on National Science Education Standards?
- ☐ Are you providing children and youth opportunities to improve their Science Abilities?
- ☐ Are you providing opportunities for youth to experience and improve in the Essential Elements of Positive Youth Development (mastery, independence, belonging and generosity)?
- ☐ Are learning experiences led by trained, caring adult staff and volunteers acting as mentors, coaches, facilitators and co-learners who operate from a perspective that youth are partners and resources in their own development?
- ☐ Are activities led with an experiential approach to learning?
- ☐ Are activities using inquiry to foster the natural creativity and curiosity of youth?
- ☐ Does your program target one or more of the outcomes on the 4-H Science Logic Model, and have you considered the frequency and duration necessary for youth to accomplish those outcomes?

(Locklear, E.L., 2013)

Appendix D

The Kentucky 4-H STEM Checklist

Cover Letter

The Kentucky 4-H STEM Checklist: Cover Letter

4-H Colleagues:

I am working on my Doctorate of Education in Educational Leadership and Policy Studies at Eastern Kentucky University. I am researching Kentucky 4-H science, technology, engineering and math (STEM) programs. The goal of my research is to investigate the efforts of 4-H programs across Kentucky related to STEM education in and out-of-school.

As part of my study, I would like to investigate what STEM programs you are offering in your county for youth in grades 4-8. Your participation in the survey is completely voluntary and will take over 5 minutes, but under 10 minutes. All information will be utilized to advocate for 4-H STEM programs across Kentucky.

The Assistant Director for Kentucky 4-H Youth Development, Dr. Mark Mains, has approved this research. An executive summary will be prepared and submitted to Dr. Mains upon completion. The Institutional Review Board has also approved this survey.

Click this link to access survey: https://uky.az1.qualtrics.com/jfe/form/SV_9zuSwSw9dVynnOl

Please limit feedback to one submission per county. I appreciate your willingness to participate. Should you have questions, please feel free to contact me at rachel.noble@uky.edu or 859-218-0991.

Sincerely,

Rachel E. Noble

Appendix E

The Kentucky 4-H STEM Checklist

The Kentucky 4-H STEM Checklist

Qualifying Questions:

I am a Kentucky 4-H Youth Development Professional serving in a county role (4-H Agent, 4-H Program Assistant).	Yes	No
I provide 4-H science, technology, engineering, and math (STEM) programs for youth in my county.	True	False

The following questions are on a Likert Scale: Always, Almost Always, Often, Sometimes, Almost Never, Never)
1) Do you provide STEM programs based on National Science Standards (For Example: Common Core, Next Generation Science Standards)?
2) Do you provide STEM programs based on 4-H curriculum and resources provided and approved through Kentucky 4-H?
3) Do you providing opportunities for youth to experience and improve in the Essential Elements of Positive Youth Development (mastery, independence, belonging and generosity) through STEM programs?
4) Are your learning experiences led by trained volunteers (volunteers in which you educate on the 4-H Program and curriculum, can be teachers, parents, community members, etc.)?
5) If volunteers do not provide your learning experience, are they led by 4-H professionals?
6) Do you collaborate with public schools in your community to provide STEM programs?
7) Do you collaborate with private schools in your community to provide STEM programs?
8) Do you collaborate with home school networks in your community to provide STEM programs?
9) Do you operate your programs from a perspective that youth are partners and resources in their own development?
10) Are activities led with an experiential approach to learning (hands-on)?
11) Are activities designed to foster the natural creativity and curiosity of youth?
12) Do you feel Kentucky 4-H provides quality training related to learning and implementing STEM programs for 4-H professionals and volunteers?
13) Do you integrate multiple disciplines into STEM lessons? (For Example, science and applied math and engineering)
14) Do you use the *Engineering Design Process*? (identifying the problem, designing the solution, testing the solution)

How often do you conduct STEM programs?	One Session	Two Sessions	Three Sessions	Four Session s	Five Sessions	More than Five Sessi ons
How often do you conduct STEM Programs?	Once a Week	Two Times a Week	Every Two Weeks	Once a Month	When the need arises	Once a year
How much time do you have to work with when conducting STEM programs with 4-H'ers?	20 minutes	30 minutes	45 minutes	1 hour	2 hours	More than 2 Hours

Select the learning environment where the majority of your STEM program efforts occur:	After School Club	Project Club	Community Club	School Enrichment	SPIN Club

Choose the topics covered in the STEM programs you offer:	Geospatial	Bio-Tech.	Robotics	Ener./ Elect.	Petro. Power	Comp. Sci.	Aero.

Please rank the barriers to offering 4-H STEM programs in your county. One being the most prevalent, six being the least prevalent. LACK OF…	Funding	Interested Youth	Support of Schools	Parent Support	Professional Devel. Opp. STEM Edu.	Interest of Vol.

How are your STEM How are your STEM programs funded? Please rank, one being the most used funding source and seven being the least used funding source.	Grants	Program Support Monies	4-H Council	School Funding	Sponsorships	Youth Pay

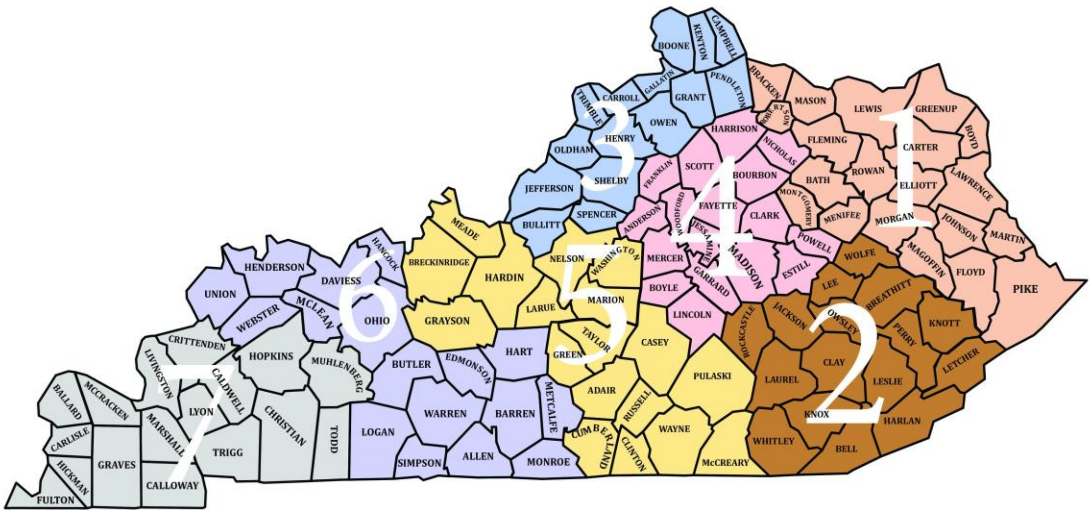
Please select the grades in which you offer STEM programs (in or out-of-school):	4	5	6	7	8

Please select your Extension District (region of Kentucky):	1	2	3	4	5	6	7

Appendix F

University of Kentucky Cooperative Extension Districts

University of Kentucky Cooperative Extension Districts



University of Kentucky: College of Agriculture, Food, and Environment (2017)