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History of Science Education in the 4-H Youth Development Program

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INTRODUCTION

The 4-H Youth Development Program has a long and proud history of helping youth develop into capable and successful adults by engaging youth in science, nutrition, leadership, and citizenship education. Begun in the vocational agricultural tradition of the early 1900's, 4-H programs were created for the purpose of transferring science-based information from land-grant universities to local communities. While an emphasis on science education has remained a pillar of 4-H programming during the past 110 years, the learning outcomes, pedagogies, and contexts in which science education takes place have evolved over time. The focus of this monograph is to highlight the trends in the rationale, learning goals, pedagogies, and contexts of 4-H science education efforts over the hundred and ten year history of 4-H.

In the U.S., improving the scientific literacy of youth has been a consistent objective over the past hundred years (Hurd, 1998). However, determining the purpose and appropriate content and pedagogy for the teaching of science in schools has had its share of conflict. Science education encompasses both products (i.e., a body of knowledge) and process (e.g., observations, designing experiments, and using reasoning skills). This dual purpose distinguishes science education from many other fields, as in most disciplines a body of knowledge is not taught alongside a set of processes (DeBoer, 1991). There are many rationales for the teaching of science in schools. Science contributes to intellectual development, the sharing of aesthetic pleasure, personal satisfaction, and advancement of knowledge (DeBoer, 1991). 4-H programs have echoed the goals of improving scientific literacy in national-level initiatives during the course of the organization's history.

This paper traces the history of science education through the 4-H Youth Development Program over the past century using four eras in time: 1900-1930's, 1960's, 1980's, and today (2000's). While these four time periods tend to blend together, taking a snapshot in time provides a framework for a comparative analysis of the progression in rationale, learning goals, pedagogy, and context in 4-H science education. These eras also correlate to historical reform movements in school-based science education, e.g., the Committee of Ten Report (National Education Association [NEA], 1893) and Cardinal Principles (NEA, 1918) influencing schools at the turn of the century; the Cold War fueled era of the 1960's, bringing back disciplinary-focused science education (Rudolph, 2002); science-technology-society approach (DeBoer, 1991) and arguments calling for "Science for All" in the 1980's (American Association for the Advancement of Science [AAAS], 1990); and a renewed focus on scientific literacy today (National Research Council, 2007).

This paper does not explicitly connect 4-H science education with formal education. Both original source documents and compilations were used to conduct an analysis of science education in 4-H during the four time periods. A wealth of 4-H history has been preserved at land-grant university libraries and by 4-H staff and

A child joins 4-H during an inquisitive age. He is naturally curious about things and will ask questions … he is capable of understanding science and he prefers to discover answers for himself. Science appeals to 4-H members.
Seevers & Quisenberry (1964, p. 24).

volunteers. These source documents, particularly national-level guiding documents, influenced 4-H programming during their time, however, the 4-H program is large and decentralized. On-the-ground programming differs from location to location, involving multiple levels of government, reliance on volunteers, and multiple delivery methods. Therefore, this article looks at trends through the lens of national 4-H reports and policy documents and does not attempt to directly assess the impact of those policies on local programs.

Structure of the 4-H Organization

4-H is administered by a cooperative agreement between the USDA, state land-grant universities, and county governments. This structure is highly decentralized and allows for local counties to adapt their programming to fit the needs of youth within their area. The USDA is responsible for national coordination, conferences and events, broad research agenda, and stewardship of the emblem. The National 4-H Council, a non-profit organization, works collaboratively with the USDA to raise funds for programming, manage curriculum development, and coordinate marketing strategies. State land-grant universities have fiduciary, liability, and programmatic oversight of 4-H programming in their respective state. Land-grant universities each develop their own 4-H policies, programs, curriculum, and research agendas. This cooperative extension structure originated with the Smith-Lever Act of 1914 and has operated largely within the same broad arrangement since that time.

The highly decentralized organizational structure provides challenges to describing the general framework of 4-H programming. Within each county, one or more cooperative extension employees (called agents, program staff, or advisors, depending on the state) are accountable for direction and oversight of 4-H programming. Primarily responsible for coordination, volunteer management, and ensuring high quality educational programming, 4-H staff do not typically have day-to-day contact with 4-H youth members. Programs rely heavily on 4-H adult volunteers to provide administrative coordination for 4-H Clubs and educational programming.

How Youth Participate in 4-H

Youth are reached by 4-H programming in a variety of ways (called delivery methods), which include 4-H Clubs, school enrichment, afterschool, and camps. These delivery methods vary by state and from county-to-county. The general frameworks used across the country are either community clubs or project clubs. Community 4-H Clubs tend to have a broader scope in their educational goals while project clubs tend to focus on one or a few content areas. 4-H Clubs are the descendants of the boys' and girls' agricultural clubs wherein youth, ages 5 through 19, join a local 4-H Club as the school year begins in the fall and participate through the following spring. 4-H members elect youth officers to run meetings and develop an annual plan of work that includes community service projects, social outings, and educational activities. In a 4-H community club, 4-H members select from a list of projects to focus on during the year. The list of available projects can vary and tends to be based on the availability of either curriculum or an adult 4-H volunteer. In addition to 4-H Clubs, 4-H reaches youth through other delivery methods, with the most prevalent being in- school enrichment activities which typically use 4-H curriculum led by 4-H staff or volunteers, afterschool programs with 4-H curricula either led by 4-H staff or volunteers, or through afterschool staff, and 4-H overnight camps.

Eras of Science Education in 4-H

This paper examines science education in 4-H at four time periods: 1910-1930's, 1960's, 1980's, and 2000's. Each snapshot can be characterized as an era in 4-H science education, based on renewed national 4-H efforts to strengthen 4-H science programming. This article situates these eras within broader societal and educational events. The first time period encompasses the beginnings of 4-H in the early 1900's through the 1940's. In this era 4-H remained within the scope of agriculture and home economics. In the late 1950's, professional 4-H educators began to talk about 'science in 4-H' and the first major national effort for science in 4-H took place in the early 1960's. Nearly twenty years later, another national effort for science and technology took place in 4-H which is examined in the 1980's snapshot. The latest efforts to strengthen science education in 4-H began in the mid 2000's and resulted in a new national initiative, '4-H Science.'

1900-1930's: Boys' and Girls' Rural Agricultural Clubs & the Smith-Lever Act

Boys' and girls' agricultural-club work as a form of rural-school extension usually centers in the competitive idea, utilized as a factor in the educational development of the individual and the community. Howe (1911, p. 20)

In 1918, the Cardinal Principles of Secondary Education were issued in part to reform high school curriculum around practical utility. The report had a dramatic impact on increasing science education in high schools around five major goals: strengthen a democratic society through a scientifically literate populace; enrich attitudes and appreciation for nature; interest students in science careers; improve science process skills (e.g., observation, classification, reasoning); and develop content knowledge (NEA, 1918). Many of these reasons for science education have been used in 4-H, albeit during different eras. At the turn of the century, workforce preparation, especially in rural agricultural areas, was the momentum behind the formation of boys' and girls' agricultural clubs (Howe, 1911; Kliebard, 1995).

The beginnings of 4-H were founded in vocational agricultural education, primarily based in rural areas (Eaton, 1931; Howe, 1911; Reck, 1951; Wessel & Wessel, 1982). During this period, the country's demographic was heavily rural with many involved in some type of agriculturally-related work. With calls for more practical science education at the turn of the century, school superintendents, university faculty, and other educators sought to teach boys skills pertaining to agriculture and girls skills for the home (Eaton, 1931). The emphasis of these programs was on teaching "how" to do something and demonstrating it by growing a crop, making a profit, and exhibiting at the fair. These methods sought to teach youth new science-based concepts, yet did not attempt to fully engage youth in the scientific process or teach about science as inquiry. The discussion of science in these boys' and girls' agricultural clubs was primarily mono-directional, with information conveyed by scientists to youth participants.

One of the first examples of club work began in 1898 in New York by Cornell University (Howe, 1911). The idea spread like wildfire to a dozen other eastern and mid-western states. During the first decade of the 20th Century, county school superintendents responded to a need for relevant and practical education and addressed concerns around lack of appreciation of nature, limited meaningful agricultural education, and farmers not accepting new scientific advances with the formation of boys' and girls' agricultural clubs during out-of-school time (Reck, 1951). Youth were primarily engaged in a community club (coed with a wide diversity of 'home projects'), a boys' or girls' agricultural club (not coed), or a group or individual home-project club (Eaton, 1931; Kliebard, 1995). These clubs typically had a specific focus, for example, youth could participate in a corn club, hog club,

Boys' and girls' agricultural-club work as a form of rural-school extension usually centers in the competitive idea, utilized as a factor in the educational development of the individual and the community. Howe (1911, p. 20).

canning club, gardening club, or tomato club. This structure organized learning around a project and became one of the primary pedagogical tools used in early 4-H programming. It has persisted to this day. In the boys' and girls' agricultural clubs, a project, or 'home project' was an organized educational experience around a particular subject matter (Wessel & Wessel, 1982). For example, a member might work on the sugar beets project in which they learned about sugar beets from an extension educator or adult volunteer, planted and grew seeds, took a field trip to an operating sugar factory, harvested their own crop, and exhibited the crop at the county fair (True, 1929).

Learning scientific principles and methods will better prepare youth for later life than learning only skills and "how-to-do-it" information which soon becomes obsolete. … A better appreciation of science will contribute to the national goals for a scientifically literate citizenry… National 4-H Club Foundation (1963, pp. 21-22).

Congress passed the Smith-Lever Act in May 1914 which officially created Cooperative Extension and placed boys' and girls' clubs within the United States Department of Agriculture (USDA) (Wessel & Wessel, 1982). Boys' and girls' agricultural clubs became the province of Cooperative Extension staff and phased out the involvement of school superintendents. National 4-H recognizes the official beginning of 4-H as occurring in 1902 (4-H National Headquarters, n.d.a). To provide a sense of size: In 1931, an estimated 800,000 youth, ages 10 through 20 were involved in 4-H (Eaton, 1931) while the U.S. population of 10 to 19 year olds was approximately 23.5 million (U.S. Department of Commerce, 1933). In 2009, over 6 million young people were involved with 4-H (4-H National Headquarters, 2009) while the U.S. population of 10 to 19 year olds was approximately 42.7 million (Howden & Meyer, 2011).

Educational Outcomes

The educational outcomes of boys' and girls' agricultural clubs were to help youth learn and practice observation, problem solving, cooperation, and compromise skills; develop social connections; improve rural communities; and improve rural schools (Howe, 1911). Many of these clubs had their own names, elected youth officers to run meetings, met outside of school, used the demonstration-method of teaching, and encouraged youth to exhibit products at county fairs (Howe, 1911). These exhibits oftentimes were contests that awarded youth for harvesting the largest crop yield or raising the optimal pig. Youth might exhibit fruits, vegetables, and farm crops they had grown. Cash prizes were given to the top winners and served as an incentive for participation. While elements of group work were present, most of the members' work was completed at home and/or on the farm. Early in the formation of agricultural clubs, parents started acting as volunteer leaders to help coordinate activities.

Project-Based Learning

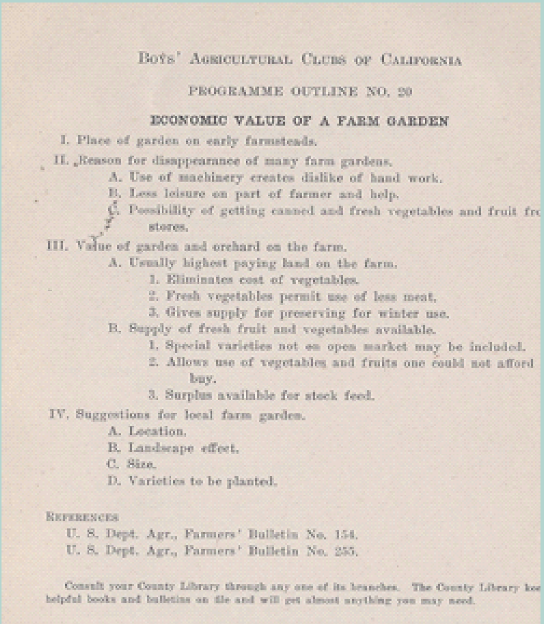
The vocational agricultural project-method had a tremendous impact on science education taking place in public schooling (Kliebard, 1995). "In the work with boys and girls, called generically the '4-H club work,' the term *project* is used much as the schoolman is accustomed to use it" (Eaton, 1931, p. 244). By the 1930's, the project-method had garnered such an extensive reach in public schooling that it became more widely known as the experience curriculum or activity curriculum (Kliebard, 1995). In fact, concern was expressed that if schools reformed to an experience/activity curriculum and club work became more educational, both would be similar rather than complimentary and might start to work at cross purposes. One author even suggested merging club work under schools (Brim, 1931). Of course, this integration did not take place, and 4-H work became the province of the land-grant university system.

Demonstration

Another 4-H teaching method during this time was the demonstration, as either a "result demonstration" or "method demonstration" (Eaton, 1931). The demonstration method relied on the extension educator showing a group of youth how to do something. This method contrasted with text-book or lecturing-based formats commonly found in schools during the period. "Under pressure of the brief contacts that tend to distinguish his work from that of the school teacher, the extension worker has developed methods objective and direct, of great merit in teaching facts, methods, and standards in a very convincing way" (Eaton, 1931, p. 255).

Example of science education in 4-H during the 1900-1930's

In California, extension administrators outlined a program of work that guided local educators, titled *Programme Outlines for the Boys' Agricultural Clubs of California* (Crocheron, 1917). The recommendations called for two meetings per month, with one as an "indoor" meeting and the other a field trip. Subject matter guidelines outlined topics and questions for each meeting. At a meeting, boys might learn about the importance of alfalfa, the economic value of farm gardens, or the characteristics of apples or pears. No emphasis was placed on helping youth learn about the scientific method, but rather, the focus was on teaching youth new skills based on university research. An example of two program outlines are included as Figures 1 and 2.



BOYS' AGRICULTURAL CLUBS OF CALIFORNIA

PROGRAMME OUTLINE NO. 20

ECONOMIC VALUE OF A FARM GARDEN

I. Place of garden on early farmsteads.

II. Reason for disappearance of many farm gardens.
   - A. Use of machinery creates dislike of hand work.
   - B. Less leisure on part of farmer and help.
   - C. Possibility of getting canned and fresh vegetables and fruit fro[m] stores.

III. Value of garden and orchard on the farm.
   - A. Usually highest paying land on the farm.
     1. Eliminates cost of vegetables.
     2. Fresh vegetables permit use of less meat.
     3. Gives supply for preserving for winter use.
   - B. Supply of fresh fruit and vegetables available.
     1. Special varieties not on open market may be included.
     2. Allows use of vegetables and fruits one could not afford [to] buy.
     3. Surplus available for stock feed.

IV. Suggestions for local farm garden.
   - A. Location.
   - B. Landscape effect.
   - C. Size.
   - D. Varieties to be planted.

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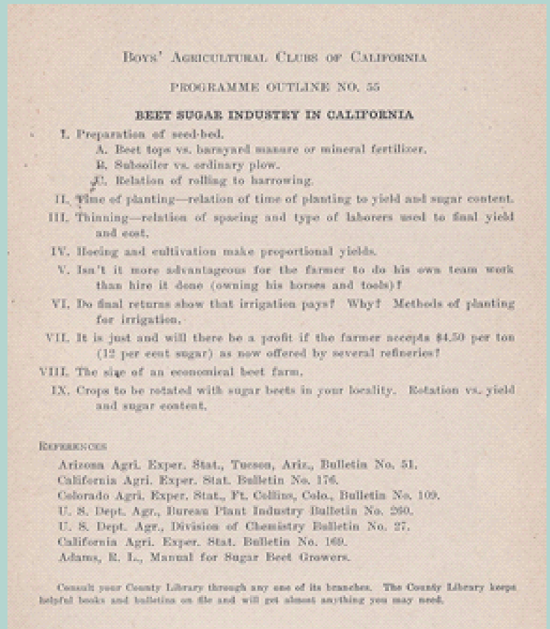
U. S. Dept. Agr., Farmers' Bulletin No. 154.

U. S. Dept. Agr., Farmers' Bulletin No. 255.

Consult your County Library through any one of its branches. The County Library kee[ps] helpful books and bulletins on file and will get almost anything you may need.

Figure 1: Programme Outline No. 20: Economic Value of a Farm Garden (Crocheron, 1917)



BOYS' AGRICULTURAL CLUBS OF CALIFORNIA

PROGRAMME OUTLINE NO. 55

BEET SUGAR INDUSTRY IN CALIFORNIA

I. Preparation of seed-bed.
   - A. Beet tops vs. barnyard manure or mineral fertilizer.
   - B. Subsoiler vs. ordinary plow.
   - C. Relation of rolling to harrowing.

II. Time of planting—relation of time of planting to yield and sugar content.

III. Thinning—relation of spacing and type of laborers used to final yield and cost.

IV. Hoeing and cultivation make proportional yields.

V. Isn't it more advantageous for the farmer to do his own team work than hire it done (owning his horses and tools)?

VI. Do final returns show that irrigation pays? Why? Methods of planting for irrigation.

VII. It is just and will there be a profit if the farmer accepts $4.50 per ton (12 per cent sugar) as now offered by several refineries?

VIII. The size of an economical beet farm.

IX. Crops to be rotated with sugar beets in your locality. Rotation vs. yield and sugar content.

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U. S. Dept. Agr., Division of Chemistry Bulletin No. 27.

California Agri. Exper. Stat. Bulletin No. 169.

Adams, R. L., Manual for Sugar Beet Growers.

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Figure 2: Programme Outline No. 55: Beet Sugar Industry in California (Crocheron, 1917)

1960's: The National 4-H Club Foundation announces SCIENCE IN 4-H

Learning scientific principles and methods will better prepare youth for later life than learning only skills and "how-to-do-it" information which soon becomes obsolete. … A better appreciation of science will contribute to the national goals for a scientifically literate citizenry… National 4-H Club Foundation (1963, pp. 21-22)

A renewed furor for school science education took place during the Cold War and Sputnik era of the 1950's and '60's (Rudolph, 2002). Many perceived the nation's security to be at risk, and there was a growing national concern about a shortage of scientists and technologists and a lack of qualified teachers. The public became frenzied about the perceived weaknesses of America's ability to maintain pace with the Soviet's scientific and technological advancements. 'Academic traditionalists' gained public and governmental support leading to significant reforms in science education. Public, government, educator, and scientist attention shifted towards reforming science education in schools from practical utility to a disciplinary, focused approach (DeBoer, 1991). School curriculum projects, like those authored by the Physical Science Study Committee, funded by the National Science Foundation (NSF), began to refocus school classrooms on core scientific concepts (Rudolph, 2002).

This national attention on science education spilled over into 4-H. While not specifically citing international fears, 4-H educators called for strengthening science education in the 4-H youth development program (Smith, 1967).

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Since its inception, delivering scientifically valid information and techniques to youth had been a pillar of 4-H programming. The emphasis, however, was typically on gaining how-to skills and not on learning the process. Advocates for increasing science education during this era in 4-H criticized 4-H clubs for not helping youth develop an understanding and appreciation for the scientific method (National 4-H Club Foundation, 1963). The response started slowly but gained momentum, especially with financial support from the NSF to study how to strengthen science education in 4-H (National 4-H Club Foundation, 1963). New curriculum, projects, and support from USDA and land-grant universities slowly began to intensify science education in 4-H.

In 1959, the Extension Committee on Organization and Policy published *A Guide to Extension Programs for the Future: The Scope and Responsibilities of the Cooperative Extension Service* (Kearl & Copeland, 1959). Known as the Scopes Report, the authors advocated the adoption of ten objectives for youth work in Cooperative Extension. Of the ten objectives for youth work, two highlighted the importance of science education to help provide opportunities for youth to grow mentally, physically, socially, and spiritually (Aiton et al., 1959, p. 29):

4. *Appreciate the values of research and learn scientific methods of making decisions and solving problems.*
5. *Recognize the importance of scientific agriculture and home economics and their relationships to our total economy.*

During this period, extension educators started to emphasize scientific inquiry, experimentation, and "science whys" in addition to "hows" in 4-H programs (Seevers & Quisenberry, 1964).

Informed by the Scopes Report and funded by the NSF, a year later the National Conference on Science in 4-H Club Work was held in Michigan (Wessel & Wessel, 1982). The meeting brought together extension educators from across the country to discuss best ways to develop challenging science-based projects for 4-H members. The NSF's interest extended to informal science education in addition to school science curriculum reform. Educators discussed how to create new projects and strengthen existing projects that would encourage youth to understand science by engaging in scientific methods (National 4-H Club Foundation, 1963).

During this period, extension educators started to emphasize scientific inquiry, experimentation, and "science whys" in addition to "hows" in 4-H programs (Seevers & Quisenberry, 1964). In 1963, the NSF funded a study on expanding science in 4-H projects, titled *Science in 4-H Study: A study of the possibilities of expanding the understanding and use of science through 4-H club work* (National 4-H Club Foundation, 1963). The report sought to identify, analyze, and recommend ways to strengthen science education in 4-H. To this end, the report stated three goals for 4-H science education to help youth (National 4-H Club Foundation, 1963, p. 17):

1. *Be curious to explore and understand why things happen as they do; in this way, to develop active, inquiring minds;*
2. *Appreciate the value of research and its endless potential for discovering newer and more accurate knowledge.*
3. *Think objectively, systematically, and imaginatively in dealing with life.*

The report outlines a rationale for science emphasis in 4-H projects, describes the methodology in which the authors' recommendations are based, and outlines recommended content, divided by age groupings, for common 4-H projects. While National 4-H Club Foundation recommended learning-by-doing, teaching science as inquiry, and helping youth develop scientific process skills, the bulk of the recommendations contained suggested content for 4-H projects. For example, in animal science, it was suggested youth should learn about the types of feed, digestive systems, and microbiology in nutrition projects were recommended that complemented school curriculum, yet identified three unique niches for 4-H projects – providing a field laboratory, introducing youth to subjects before they were studied in school, and focusing on subject areas for which schools did not provide training.

Increasing the emphasis on science education in projects required changes to programming and recognition systems (National 4-H Club Foundation, 1963). Training aids and workshops needed to help adult volunteers become comfortable

Examples of how science education in 4-H was encouraged during the 1960's era:

"Has your club tried applying science to 4-H project work?" asked an article in the National 4-H News (Shaffer, 1964a). The article described a pilot study in North Carolina to test new 4-H science-based project materials. In one setting, 4-H members studied soil, surveyed rainfall, and experimented with seeds. The new project materials encouraged 4-H members to start with the easy activities and progress to harder exercises. The authors of the materials tried to make the activities complement the school curriculum.

In 1964, the National 4-H Club Foundation released five science kits for purchase. The kits contained an "easy-to-follow" project book and supplies. The curriculum units were designed to help youth learn about seeds, magnets, astronomy, maps, and fossils (Shaffer, 1964b).

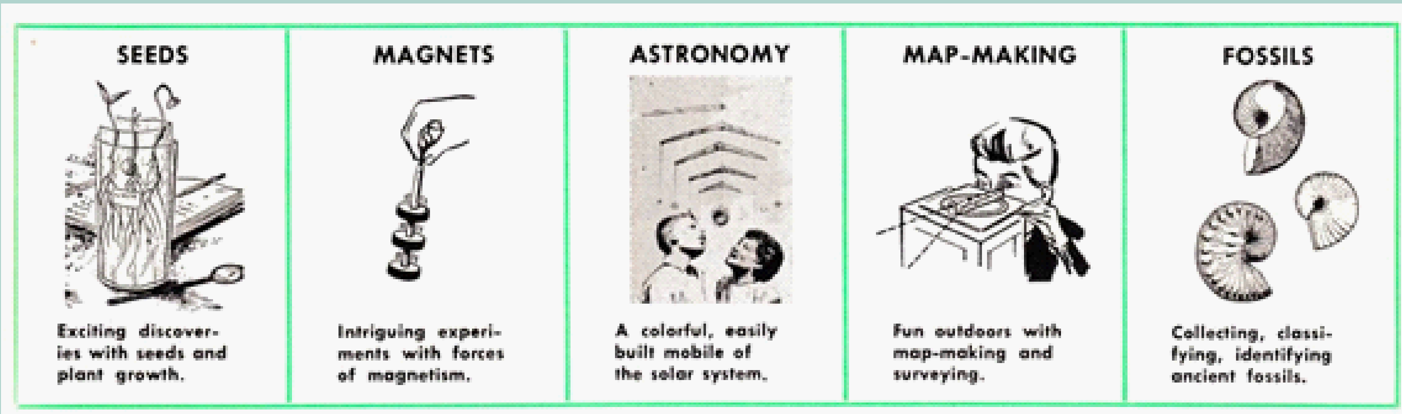

Figure 3: 4-H Science Kits Available for Purchase, developed by Science Materials Center, Inc.

with science topics. Venues needed to be identified for members to demonstrate and showcase their project work. The report conducted by the National 4-H Club Foundation addressed these challenges and offered potential solutions including comprehensive volunteer trainings and new recognition systems.

1980's: Science and Technology: The 4-H Way

The key to the success of the 4-H approach to science education is hands-on, learning-by-doing, practical real-world application of scientific knowledge, as a means of reaching a goal which is important to the young participant.
Cooperative Extension System (1987, p. 4)

From the 60's to the 80's, U.S. science educators began to focus on 'science for all Americans' and the connections between science, society, and technology (AAAS, 1990). New calls were heard for the reorganization of science around relevant social issues, practical curriculum emphasizing technology, and renewed interest in helping children develop necessary scientific skills. During this era, 4-H educators reframed the message to underscore the importance of youth developing universal scientific skills, rather than content-specific skills. Extension educators emphasized the critical importance of experiential learning, cooperative learning, inquiry-based instruction, and use of scientific skills such as observing, communicating, comparing, organizing, relating, experimenting, inferring, and applying (Ponzio, 1994).

In the 1980's, public school reformists advocated for a relevant school curriculum that integrated science, technology, and society. "Scientific literacy" was the term popularized by the movement (DeBoer, 2000). This concept was defined in multiple ways, yet at its core included a functional understanding of science concepts, the scientific method, and the role of science in society. The National Science Teachers' Association (NSTA) issued a position statement that identified science literacy as the most important goal of science education (DeBoer, 1991). The

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The "real focus on utilizing the experiential learning cycle and other components of John Dewey's philosophy on education and experiences first came about with the development of 4-H science curricula" (Enfield, 2001, p. 9).

NSTA outlined themes of social relevance, student interest, science and technology, and the sociopolitical aspects of science. Another term, science-technology-society (STS), also became widely used to describe the goals of science education as being a human activity, relevant, value-oriented, and concerned for the wider human and natural world (Deboer, 1991).

In 1987, the USDA Cooperative Extension System released a report, titled *Science and Technology: The 4-H Way. Status Report: 1986* (Cooperative Extension System, 1987). The report stressed the need for more scientists and engineers to help maintain America's competitiveness internationally. The report outlined the strengths of 4-H in "involving youth in using science to solve their own real-world problems, in a stimulating and realistic fashion" (Cooperative Extension System, 1987, p. 3). The report advocated for:

- Embracing mathematics, astronomy, and physics (as recommended by the NSF in 1977).
- Preparing educational programs to be broadcast over the television to reach new audiences.
- Preparation of project-specific materials which emphasized the science connection of the material.
- Continuing to enrich school curriculum with agriculture and food subject matter.

Experiential Learning

The emphasis on scientific literacy in 4-H helped frame curriculum and projects around the experiential learning cycle (Kolb, 1984). Experiential learning helps youth make meaning from direct experience. The "real focus on utilizing the experiential learning cycle and other components of John Dewey's philosophy on education and experiences first came about with the development of 4-H science curricula" (Enfield, 2001, p. 9). While there are multiple models, the basic components are engaging youth in an experience, reflecting and making sense of the experience, generalizing and applying to new situations. While 4-H programming had always had a hands-on approach, the framing of activities in the learning cycle helped strengthen the educational value of 4-H experiences. A goal of engaging youth in 4-H science-type projects was formed to help youth "develop a positive attitude" towards science. The goal also implied that their 4-H projects "awakened an interest in the sciences" (Cooperative Extension System, 1987, p. 4).

Growing Emphasis on Improving Attitudes

Awareness started to surface about the effect attitudes towards science and technology had on youth's future selection of educational and career choices

Examples of how science education in 4-H was encouraged during the 1980's era:

A 4-H member might enroll in a 4-H gardening project to learn about how to grow his/her own garden (Cooperative Extension System, 1987). 4-H volunteers leading the project were encouraged to incorporate aspects of science-based information into the project, such as soil science, botany, use of gardening tools, and hands-on activities. After a few years, the 4-H member might start to design and plan his/her own experiments to try in the garden.

In California, 4-H educators designed a new 4-H science curriculum set titled, "4-H Science Experiences and Resources for Informal Education Settings" (4-H SERIES), funded by a NSF grant (Ponzio, 1994). 4-H SERIES curricula were devised to help 4-H members develop competence in science processes, such as observing, comparing, inferring, and applying. Curriculum topics ranged from agriculture to chemistry, from oak woodlands to recycling. The content subject matter was viewed as having secondary importance to engaging youth in science process skills. Each curriculum module helped adult 4-H volunteers lead projects with youth members using the experiential learning cycle and applying knowledge through a community service project.

Figure 4: 4-H SERIES Curricula Logo (late 1980's)

(Cooperative Extension System, 1987). Extension educators proposed research on how involvement in 4-H might impact youth electing to attend a land-grant institution, and whether activities on a college campus might influence youth to attend that college.

2000's: 4-H Science, Engineering, and Technology (SET) Education

4-H Science, Engineering, and Technology combines the strengths of 4-H programming and non-formal, experientially-based delivery modes with strong youth-adult partnerships to address content as defined by the National Education Science Standards in order to prepare youth to compete in the 21st century workplace. Kress, McClanahan, & Zaniewski (2008, p. 10)

At the beginning of the 21st century, the value of science education, both in and outside the classroom, had attained higher levels of public acceptance (Falk & Dierking, 2010). A plethora of science centers, television shows, and science-based informational websites were readily available. However, reports had shown a stagnation and in some cases, decline, in the numbers of youth seeking an education or career in a science, engineering, or technological field. In *Rising Above the Gathering Storm*, the National Academies (2007) addressed the critical need for academic and vocational experiences in science and technology and raised the alarm of maintaining America's innovative edge. Debates abounded on appropriate content, pedagogy, and relevance of curriculum. The National Science Education Standards (National Research Council, 1996) and Project 2061 (AAAS, 1990) advocated for increased teaching of science by inquiry and making curriculum accessible to all students.

In 2008, 4-H National Headquarters renewed 4-H's commitment to science education by announcing the 4-H Science, Engineering, and Technology (SET) Initiative (4-H National Headquarters, 2007). This initiative was one of three mission mandates to focus 4-H programming on science, healthy living, and citizenship, with content to be delivered in a positive youth development context (4-H National Headquarters, n.d.b). The addition of engineering and technology reflected the growing number of 4-H projects based on engineering and technology. In 2010, 4-H National Headquarters renamed the initiative to "4-H Science" (J. Kahler, personal communication, May 12, 2010). The initiative, as with earlier efforts in the 60's and 80's, emphasized the need for additional science education in 4-H, improved training for 4-H volunteers, strengthened 4-H curriculum, and incorporated a more comprehensive strategy, to include evaluation, marketing, funding, and partnerships (4-H National Headquarters, 2007).

Emerging research suggested out-of-school-time (OST) educational programs, when properly structured and facilitated, could increase science interest, positively influence academic achievement, and influence youth's future career choices (National Research Council, 2009). In the position paper, *Revisiting How the US Engages Young Minds in Science, Engineering, and Technology*, the authors advocated for more attention to the out-of-school hours. "OST programs in SET play a vital role in meeting students' needs once the final school bell has rung and are viable pathways for engaging and inspiring America's future scientists and engineers" (Kress, et al., 2008, p. 4).

The guiding document for this new initiative, *4-H Science, Engineering, and Technology: A Strategic Framework for Progress*, outlined the expected outcomes for 4-H youth through their involvement in 4-H Science (4-H National Headquarters, 2007, p. 5):

- *4-H youth are more attentive and show improvement in science, engineering and technology subjects in school.*
- *4-H youth express interest in pursuing science, engineering and technology college courses and careers.*
- *The number of females and minority youth involved with 4-H SET programs increases.*

4-H Science, Engineering, and Technology combines the strengths of 4-H programming and non-formal, experientially-based delivery modes with strong youth-adult partnerships to address content as defined by the National Education Science Standards in order to prepare youth to compete in the 21st century workplace. Kress, McClanahan, & Zaniewski (2008, p. 10).

- *Youth address community issues with their SET knowledge and skills.*

4-H Science Programming Core Values

The National 4-H Science Initiative integrated a set of content, context, and pedagogical strategy best practices into a guiding document for local 4-H programming. This approach provided an integrated framework, integrating relevant aspects of science education into a coherent whole. The National 4-H Science Leadership Team, responsible for developing the initiative, created the 4-H Science Checklist (n.d.), which was intended to help local 4-H volunteers determine if their projects exemplified high-quality science education programming. The checklist indicated 4-H science education programs should:

The National 4-H Science Initiative integrated a set of content, context, and pedagogical strategy best practices into a guiding document for local 4-H programming.

1. Be based on content in the National Science Education Standards (NSES).
2. Place emphasis on helping youth improve their science process skills (labeled 'Science Abilities' in Horton, Gogolski, & Warkentein, 2007).
3. Conduct programming within the context of positive youth development, specifically the 'Essential Elements of positive youth development' (Martz, Mincemoyer, & McNeely, 2009).
4. Encourage youth-adult partnerships.
5. Frame learning experiences in the experiential learning cycle.
6. Facilitate activities using inquiry-based teaching methods.
7. Consider the frequency and duration necessary to achieve desired youth outcomes.

The decision to base subject matter on the NSES, instead of priorities determined by 4-H staff, continued a trend in 4-H of decreasing the emphasis on content, and increasing the value of engaging youth in science processes, inquiry, and the development of life skills. The experiential learning cycle, first introduced decades earlier, had become a foundation of 4-H programming, however, many extension educators had started to emphasize the need to also use inquiry-based teaching instruction. The 2008 4-H Science Initiative placed inquiry-based instruction front and center.

Comparing the Four Eras

4-H has included science since the program's founding in the early 20th century. However, a progression has taken place from simply using the latest scientific advancements to learning about science content and science practices. Only in the late 1950's did extension educators start to emphasize science education in 4-H. During the hundred-year history of 4-H, other changes can be seen in the rationale for the teaching of science, the learning objectives in content, skills, and attitudes, the pedagogical methods, and contexts. This section compares the four eras, 1930's,

Examples of how science education in 4-H was encouraged during the 2000's era:

In Sacramento, California, elementary school students attended the overnight "On the Wild Side" environmental education camp (Bird, 2010). Trained teens delivered programming on water education, geology, and trees by engaging youth in investigations, open-ended questions, and using science tools. Youth recorded data in journals. Pre- and post-tests demonstrated their gain in knowledge about concepts presented at the camp.

Relative to engineering, 4-H members learned about robotics and the connected scientific and technology concepts through 4-H robotics curriculum (Mahacek & Worker, 2011). Using household items, 4-H members completed simple design challenges, and were guided by the adult or teen facilitator in processing, generalizing, and applying the experience.

Figure 5: Original National 4-H Science, Engineering, and Technology Initiative Logo

1960's, 1980's, and 2000's, on four domains: the rationale for science education in 4-H, expected youth learning outcomes, pedagogy, and context. Table 1 provides a quick overview of these comparisons.

Rationale for Science Education in 4-H

Over the last century, the rationale for the teaching of science has shifted, in both the public education system and in 4-H programming. Arguments have been made for the teaching of science in order to prepare children for life (e.g., Spencer, 1860), to support the functioning of a democratic society (e.g., Cardinal Principles by NES, 1918), or to maintain the competitive edge of American society (e.g., The National Academies, 2007). These same arguments have also been used to justify the teaching of science in 4-H. At the turn of the 20th Century, educators wanted to disseminate the latest advancements in agricultural science to rural farm communities. They advocated for teaching children practical skills through these methods because youth would soon enter the workforce and become farmers themselves. In the 60's, 4-H educators justified the teaching of science to prepare youth to become scientifically literate and therefore contribute to greater national productivity. While the *Sputnik* area of the 1960's caused alarm regarding national competitiveness, the justification for teaching of science in 4-H because of international competition didn't surface directly until the mid-1980's. The 80's 4-H educators recognized that 4-H could help increase the number of youth pursuing higher education in the sciences, with a particular emphasis on agricultural science. Today, the justification of science in 4-H follows that of many other science education organizations: science literacy as a prerequisite for civic discourse, and the need to increase the numbers of youth pursuing careers and education in science, engineering, and technology (DeBoer, 2000; Kress, McClanahan, & Zaniewski, 2008).

Expected Youth Learning Outcomes

The learning goals of 4-H science education programs, including the skills, content, and attitudes, have also transformed over time.

Skills: 4-H programs have always emphasized the development of practical and relevant skills. The difference, however, has been the broadening of the types of skills considered relevant and appropriate. In the beginning, skills relevant to the farm were stressed while today a much broader set of science, engineering, and technology skills is emphasized. Today, 4-H educators encourage all 4-H projects to focus on thirty science, engineering, and technology abilities, ranging from science inquiry to engineering design (Horton, Gogolski, & Warkentien, 2007).

Content: 4-H has always organized projects around functional areas and not around the science disciplines more commonly found in universities (e.g., chemistry, biology, physics). In the 1910's, 4-H programs primarily included agriculture and home economics content as outlined by program bulletins (Crocheron, 1917). As 4-H matured, agricultural science continued to be an educational emphasis, yet content learning broadened to other areas in science and technology, including climatology, electricity, computers, and social science. The 1960's also saw a growing emphasis on teaching science as inquiry, which mirrored similar recommendations by scientists over time to public schools. The list of 4-H project areas continued to grow and less emphasis was placed on providing project bulletins/outlines. Now, the list of 4-H projects on a national basis is extremely lengthy and 4-H educators are recommended to select appropriate content based on the National Science Education Standards (Horton, Gogolski, & Warkentien, 2007). The 4-H program has come a long way from its rural beginnings emphasizing content knowledge and skill building, to an emphasis on general science literacy.

Attitudes: A tranformation has taken place in 4-H from emphasis in developing content knowledge to that of improving youth attitudes toward science and technology. The importance of influencing youth opinions towards science and engineering started to be recognized in

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the 1960's, yet did not achieve an explicit place in programming until the new century. In today's 4-H programming, the improvement of youth attitudes towards science and technology is considered just as important as gaining content knowledge; e.g., the national 4-H evaluation framework highlights attitudes, knowledge, and engagement (Mielke, LaFleur, & Sanzone, 2010). Research in youth science education has recognized the niche out-of-school time programs play in offering youth opportunities to develop an appreciation for science and technology (Maltese & Tai, 2010; National Research Council, 2009).

Pedagogy

The project-method, the foundational element of boys' and girls' agricultural clubs, remains the basic organization of 4-H Club work today. Similar to the beginning of 4-H, youth today enroll in one or more projects, and are guided by an adult volunteer in learning about the subject matter. They may build an exhibit, and showcase their exhibit at some type of show or event. From the very beginning of 4-H "hands-on learning" has been a significant pedagogical tool used by volunteers to engage youth in learning (Cooperative Extension System, 1987; Eaton, 1931; Enfield, 2001). The research and techniques behind the pedagogy has progressed over the past hundred years, but at its core, the concepts of intentional learning remain a pillar of the 4-H educational philosophy. As voiced by an extension educator, "The tradition of 'learning by doing' stemming from the original demonstration projects in 4-H continued through the decades and is still the backbone of the 4-H Youth Development Program in the 21st century" (Enfield, 2001, p.3). However, the demonstration model utilized heavily in the first half of 4-H history has been deemphasized as a pedagogical tool in place of emphasizing the learning cycle and inquiry-based instruction. Remnants can still be seen; for example in the 4-H public speaking manual, the 'demonstration' is a primary format youth use to present to an audience (Fraser & Engebreth, 2005).

"The tradition of 'learning by doing' stemming from the original demonstration projects in 4-H continued through the decades and is still the backbone of the 4-H Youth Development Program in the 21st century" (Enfield, 2001, p.3).

Context

The organized 4-H Club remains as a fundamental organizational structure of 4-H programming. Over time, partially in response to the need to reach underserved audiences, 4-H programming has developed other methods to reach youth (Wessel & Wessel, 1982). 4-H became disconnected from schools in the middle of the century, yet in the 1980's, 4-H school enrichment programs became a strategy to expand 4-H's reach to new audiences. Today, 4-H reaches youth in afterschool programs, summer residential camps, and other special short-term projects.

Positive youth development is the context of programming wherein youth cultivate the positive assets they need to lead successful and contributing lives (Lerner, von Eye, Lerner, Lewin-Bizan, & Bowers, 2010). 4-H programming strives to help youth develop life skills, such as leadership, citizenship, teamwork, communication, reflection, and organization. These youth development outcomes transcend the curricula. While the project serves as an immediate incentive - a spark to develop interest - the long-term learning outcomes of 4-H over the past hundred years has been the development of caring and capable citizens. One of the clear differences between 4-H today compared with that of previous eras is understanding the importance of delivering the 4-H program within the context of positive youth development.

Conclusion

In the book, *A History of Ideas in Science Education*, DeBoer outlines the three recurring interpretations of the teaching of science in schools during the past hundred years (DeBoer, 1991, p. 219):

1. *Teaching the science disciplines as structured bodies of knowledge to be learned as logically organized subject matter.*
2. *Teaching science as a set of investigative processes.*
3. *Teaching science as a human activity closely interconnected with its technological applications and with the rest of society.*

DeBoer postulates that the dominant form during the past one hundred years is the teaching of science as a structured body of knowledge. The 4-H Youth Development Program did not always follow the pattern of science education found in schools. Instead, founded in the traditions of vocational agricultural education and moving towards a positive youth development approach, 4-H programming has grown to emphasize learning practical applications while emphasizing the scientific approach of experimentation and exploring "why."

The 4-H Way

"The 4-H Way" has been a slogan used by extension educators and volunteers during the past hundred years to describe the uniqueness of 4-H activities. When used to describe the 4-H educational philosophy of the time period, the changes in the meaning illustrates how science education has transformed in 4-H.

- In the early 20th Century, The 4-H Way was the right way to do a job with emphasis on production, skills, shows, and awards.
- In the 1960's, The 4-H Way was preparing youth for decision-making and the responsibilities of adult life. Educators placed less value on the 'right' way to do something and tried to help youth understand why something happened.
- In the 1980's, The 4-H Way was involving youth to use science to solve real-world problems.
- Today, The 4-H Way describes the pedagogy and context of 4-H programming as experiential learning and positive youth development.

The 4-H Way of science education began with a focus on agricultural content and practical skills and has progressed to an emphasis on providing learning experiences where youth develop 1) science process skills; 2) appreciation for science, engineering, and technology; and 3) citizenship, leadership, and life skills. This progression underscores the strengths and potential for the program in the next hundred years to come. ■

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Table 1: Comparison between science education in 4-H at four time periods

	1900-1930's	1960's	1980's	2000's
Rationale for Science Education in 4-H	Disseminating new university scientific advancements in agriculture to rural communities; Help youth develop practical skills in agriculture and home economics	Preparing youth to be scientifically literate will lead to greater national productivity; 4-H uniquely supplements training in home and school; Improve 4-H programs by helping youth understand 'why' and not only 'how'	Fears of international competition; Growing awareness for need to increasing number of youth to pursue higher education especially in agriculture	Science, engineering, and technology literacy a prerequisite for civic participation and workforce; recognition of role of out-of-school time programs; Need to increase number of youth pursuing college degrees and careers and improving attitudes, knowledge, and skills in SET
Learning Outcomes: *Content Knowledge*	Agriculture and home economics as outlined by program bulletins	Emphasis on agriculture, yet much broader list of content areas (approx. 70 nationally) as outlined by project standards; Science as inquiry	Animal science, nutrition, natural resources, healthy, plant science, aerospace, energy, and earth science as outlined in 4-H and other curricula	Project content based on the National Science Education Standards
Learning Outcomes: *Skills*	Practical and relevant skills, such as raising animals, food preservation, or maintenance of farm machinery	Observation, identifying, classifying, comparisons	New focus on 'process of scientific inquiry' including observing, communicating, comparing, organizing, relation/experimenting, inferring, and applying	Thirty Science, Engineering, and Technology Abilities, for example: construct, categorize, collect data, communicate, compare, design/develop solutions, draw, evaluate, infer, reason, observe, optimize, organize, predict, question, redesign, summarize, test, and use tools
Learning Outcomes: *Attitude*	No direct references	Need for a better appreciation of science	Critical to instill positive attitudes in youth towards science and technology	Emphasis on helping youth develop appreciation of science, engineering, and technology; attitudes influencing college and career choices
Pedagogy	Hands-on projects; teaching using demonstrations	Hands-on projects; teaching using demonstrations; new emphasis on allowing older members to experiment	Hands-on projects; experiential learning cycle "Learn-by-doing"	Hands-on projects; experiential learning cycle; inquiry-based instruction
Context	Organized general, project, and home clubs	Organized general and project clubs; strong emphasis on helping youth develop life skills	Organized general and project clubs; school enrichment; and growing emphasis on youth development	Organized general and project clubs; school enrichment, afterschool, camps, short-term projects; overarching foundation of in 4-H positive youth development environment
Challenges for Strengthening Science Education in 4-H	Focus on awards emphasis on the 'right' way to do things	Volunteers uncomfortable with science; focus on the 'right way' for exhibits and competing for awards	Need for volunteer training; institutional buy-in from staff and volunteers	Need for staff and volunteer training; decreased public funding support; need to overcome agricultural stereotype and recruit new youth

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