LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2016, VOL.11 , NO.18,11675-11698

Environmental Science and Engineering Merit Badges: An Exploratory Case Study of a Non-formal Science Education Program and the U.S. Scientific and Engineering Practices

Matthew E. Vick[a] & Michael P. Garvey[b]

[a]University of Wisconsin, USA, [b]Whitewater Johnson Creek School District, USA

ABSTRACT

The Boy Scouts of America's Environmental Science and Engineering merit badges are two of their over 120 merit badges offered as a part of a non-formal educational program to U.S. boys. The Scientific and Engineering Practices of the U.S. Next Generation Science Standards provide a vision of science education that includes integrating eight practices that engage youth in inquiry-based learning and investigative design and interpretation. This exploratory study uses document analysis triangulated with a questionnaire under the general principles of program evaluation as a case study to examine the potential alignment of the Boy Scouts of America's Environmental Science and Engineering merit badges and the Scientific and Engineering Practices of the NGSS. Merit badge requirements were matched with specific elements of the S&EP as described by the NGSS Appendix F progressions for middle school aged youth. The cognitive demand of the requirements was also analyzed using Webb's Depth of Knowledge. Questionnaires were sent to volunteer merit badge counselors for one Midwestern U.S. Boy Scout council. Their responses were used to inform the analysis of the merit badge requirements. The requirements for both of these badges show connections to several of the S&EP, especially S&EP 3: conducting investigation and S&EP 6: constructing explanations and designing solutions. Triangulating data from merit badge counselors show that Scouts in Engineering merit badge do engage in the engineering design process very much and potentially engage them in investigations and construction of explanations with Environmental Science. Several of the merit badge counselors were highly educated scientists and engineers. Often, these counselors reported engaging Scouts in a manner closest to the vision of the NGSS S&EP. One of the limitations of the Environmental Science merit badge is that investigations are mostly elective options. This exploratory study concludes that the requirements for Boy Scout merit badges are designed in manners that can engage youth in the S&EP. Counselors do affect the extent to which these practices are incorporated. Future studies should examine the learning by youth from merit badges as related to S&EP and general science and engineering content knowledge.

KEYWORDS
Engineering education, informal education, Environmental education (EE)

ARTICLE HISTORY
Received October 28, 2016
Revised November 24, 2016
Accepted November 27, 2016

Introduction

The Boy Scouts of America is a non-formal educational program offered to boys ages 6-11 in the Cub Scouting program, boys ages 11-18 in the Boy Scouting

CORRESPONDENCE Vick, Matthew E vickm@uww.edu

program, and both young men and women ages 14-21 in the Venturing program. The Boy Scouting program offers an advancement program that is self-paced by boys. Many of the requirements relate to environmental stewardship and education. The highest rank in Scouting is that of Eagle Scout. A major portion of the upper level advancement program involves boys earning merit badges that have requirements set by the national organization. These merit badges can also be earned out of general interest by boys even if earning the rank of Eagle Scout is not a goal. One requirement to earn Eagle Scout is to either earn the Environmental Science or Sustainability merit badges. There are also many other science and engineering merit badges such as Bird Study, Welding, Soil and Water Conservation, and Engineering. This study will analyze the connection between the Environmental Science and Engineering merit badges and the Scientific and Engineering Practices of the Next Generation Science Standards (NGSS).

LITERATURE REVIEW

Informal science education is defined by the National Academy of Sciences as “learner-motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, and open-ended (Falk and Dierking, 2000; Griffin, 1998 as cited by NAS, 2013). A variety of studies have found evidence for different impacts due to informal science education: improving interest, confidence, and engagement with science (Ferreira, 2001; Hofstein & Rosenfeld, 1996; Krapp & Prenzel, 2011; Ramey-Gassert, Walberg, & Walberg, 1994; Rennie & McClafferty, 1995; Tran, 2011), increasing knowledge about the nature of science as a way of knowing by Native American communities (Bang & Medin, 2010), and a general value for interactivity and “hands on” experiences (Falk et al, 2004).

Attitudes have been found to be more important than achievement for middle school youth to engage in science and technical career goals (Tai et al, 2006). Positive findings between engagement in an informal science education programs and attitudes by minority youth (Bouzo, 2012; Rahm & Ash, 2008). Interactive displays were found to increase interest in science with some knowledge gains by elementary aged youth and interest gains by middle school youth (Sample McMeeking et al, 2016). Overall, the assessment of learning by participants through informal science education has lacking in part because of the variety of informal settings and environments such as museums, traveling displays, camps, zoos, etc. (Allen et al., 2007; Falk & Dierking, 2000; Martin, 2004). Other studies also conclude that enthusiasm and interest in informal science education can be related to learning (Jolly, Campbell, & Perlman, 2004; Renninger, Hidi, & Krapp, 2014; Singh, Granville, & Dika, 2002). Boy Scouting’s merit badge program attempts to engage middle school boys in science and technical career goals through many of its merit badges. It seeks to both create enthusiasm for these topics and also to lead to learning. Direct assessment of the effectiveness of learning by merit badges is also an unstudied area, as with other forms of informal education.

Riedinger (2015) investigated how an informal science education camp affected the identify of young people. She found that their perceptions of self in science were affected by both school science and informal camp norms, rules, and ways of being. Due to the lack of formal assessment and differences in science discourse, youth renegotiated their normal power and social identities in the camp setting. Boy Scout merit badges are often earned as a part of a summer camp program. Summer camp staff are typically college-aged youth rather than a science or engineering professional that would counsel the badge in other environments. A local Boy Scout council hires these staff members. Environmental science is often taught by the Nature or Ecology/Conservation Director (who is often over 18 years of age and majoring in a scientific or educational field). This director typically also attends a weeklong certifying experience by the Boy Scouts of America called “National Camping School” which also provides background for teaching this merit badge. Engineering merit badge is not offered as extensively at summer camps.

The Scouting program can be identified as an informal learning environment due to several factors: (1) Scouts choose merit badges based upon their own learner interests at the time of their choosing, (2) the merit badge work often has requirements that situate the topic in the boy’s own life, and (3) the merit badge program is based upon a method of positive adult association which offers the boy the opportunity to collaborate with an adult mentor with a hobby or professional interest in the field. These adult mentors register with a local Boy Scout council. This process includes indicating how ones hobbies or profession give the person the ability to counsel a specific badge. A local advancement committee of volunteers approves these applications. The specification for expertise is that a person “be recognized as having the skills and education in the merit badge subjects covered and hold any required qualifications and training as outlined in the Guide to Safe Scouting or the Guide to Advancement—or use others so qualified (BSA, 2013).” Environmental science and engineering merit badges have no additional qualifications listed in those guides.

Scouting also has features that are not aligned with information education such as its extrinsically motivating advancement program (merit badges and ranks). Additionally, while merit badges can be earned at any time between the ages of 11 and 18, certain topics are guided by extrinsic motivation rather than learner interests by their inclusion on the required merit badge list for the rank of Eagle Scout. Environmental Science is one such merit badge and is thus taken by many Scouts out of a desire for advancement rather than personal learning. Scouting also has authority figures (adult volunteer leaders) that set it apart from much other informal education. For this reason, Scouting can be considered to be "non-formal" education (Haim, 2007) because it is in a space between formal, school-based education and the more non-linear, non-directed informal education of museums, family trips, and natural environments.

Scouting's merit badge program connects with many of the conclusions of the National Academies of Sciences (NRC, 2013). Conclusion 1 stated that "Across the life span, from infancy to late adulthood, individuals learn about the natural world and develop important skills for science learning (p.292)." Scouting addresses this by providing programming from ages 6-21. The Boy Scouting program specifically addresses this through its merit badge program for ages 11-18 which permit boys to select science, technology, or engineering badges such as Mammal Study, Automotive Maintenance, or Veterinary Medicine at any point, and in any order, through their teen years.

Conclusion 2 states that "A great deal of science learning, often unacknowledged, takes place outside school in informal environments—including everyday activity, designed spaces, and programs—as individuals navigate across a range of social settings (p.293)." Scouting takes place in the natural world on hikes, camping trips, and excursions; in museums and informal learning environments through merit badge clinics hosted by staff or trips designed by volunteer leaders; and in homes through individual merit badge counseling sessions with a boy or group of boys and a volunteer merit badge counselor who is an expert on the topic.

Conclusion 3 sates in part that "Learning science in informal environments involves… learning science practices... Informal environments can be particularly important for developing and validating learners' positive science-specific interests, skills, emotions, and identities (p.294)." This study seeks to explore the learning about science practices as defined by the Scientific and Engineering Practices (S&EP) from the NGSS (NGSS Lead States, 2013).

Conclusion 11 builds upon this momentum by stating that "…mentors play critical roles in supporting science learning (p.302)." Volunteer merit badge counselors play this mentoring role for Boy Scouts. Conclusion 12 connects with Scouting in that it states that "Programs for school-age children and youth… are a significant, widespread, and growing phenomenon in which an increasing emphasis is placed on science." Science, technology, engineering, and mathematics (STEM) have become a focus for the Boy Scouting program since it recently introduced a STEM specific program for Cub Scouts, Boy Scouts, and Venturers called the Nova and Supernova Awards program (www.scouting.org/STEM). For the Boy Scouts, part of earning some of these awards involves electing to earn Environmental Science or Engineering merit badges. Finally, this study is a partial response to Recommendation 5 that "Researchers… should broaden opportunities for publication of peer-reviewed research and evaluation (p.309)." Scouting continues to be a poorly-researched science education program (Jarman, 2005). While not directly related to informal STEM education, Polson et al (2013) found that men who were highly involved with the Boy Scouts were more likely to be active in their community than those who were never Scouts or were minimally involved. Scouting was concluded to foster behaviors that build social capital and civic engagement. This relates to the findings of a nationwide, randomized sample of men was conducted by the Gallup Organization and analyzed by Jang, Johnson, and Kim (2012). They found that Eagle Scouts are 89% more likely than other Scouts and 92% more likely than non-Scouts to be active in a groups that are organized to protect the environment. Eagle Scouts are also 38% more likely to avoid using products that harm the environment than all Scouts and 31% more likely than men who have never been Scouts. Finally, Eagle Scouts are 75% more likely than other Scouts to report trying to reduce household water consumption than all Scouts, however there was not a statistically significant difference with non-Scouts. These two studies show that Scouting can be associated with positive outcomes related to involvement with environmental issues. These survey results show the promise of the effect of learning from the informal Scouting program in terms of attitudes and behaviors. This study seeks to further help to fill this gap by researching how two STEM-based merit badges connect with the formal NGSS vision of learning about scientific and engineering practices through its non-formal program.

CONCEPTUAL FRAMEWORK

The Scientific and Engineering Practices (S&EP) found in the NGSS were developed by the document *A Science Framework for K-12 Science Education* (NRC, 2012). They stated that they used the term "practices" rather than previous terms such as "science processes" or "inquiry" in order to "emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice (NRC Framework, 2012, p.30). The eight S&EP are listed in Table 1.

Table 1
Scientific and Engineering Practices (NGSS Lead States, 2013)

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

These eight practices are further developed and a progression of the practices across grade bands (K-2, 3-5, 6-8,9-12) are given in Appendix F of the NGSS. These progressions were used as the conceptual framework for analyzing the merit badge requirements for the Environmental Science and Engineering merit badges.

Further, Webb's (1997, 1999) Depth of Knowledge framework is also used to classify the requirements in terms of the depth of non-formal learning implied by the requirements. Level 1 requires recall and reproduction. Level 2 requires the use of skills and understanding in routine, non-novel tasks. Level 3 involves the strategic use of knowledge and skills in a unique, non-routine manner (such as comparing, analyzing, or revising a procedure). Level 4 requires extended thinking such as designing or synthesizing.

This exploratory case study uses elements of program evaluation similar to that used to evaluate a pilot Scouting program in the Chicago area that was more culturally relevant for non-majority youth (Chyung et al., 2013). The study seeks to find evidence regarding the effectiveness of the Environmental Science and Engineering merit badges as programs that support adult volunteers in engaging youth learning about the scientific and engineering practices found in the NGSS with deeper levels of Webb's DOK. This study does not yet seek to study the effectiveness of learning by the Scouts themselves, it focuses upon the intention of the requirements and their implementation by counselors. The ten steps for conducting an improvement-oriented program evaluation (Davidson, 2005; Scriven, 2007) used by Chyung et al. were adapted to this smaller scale, exploratory study. The use of these ten steps is detailed below.

1. *Identify the evaluand*: The structure of the Environmental Science and Engineering merit badges and their implementation are evaluated.
2. *Identify the overall purpose and types of evaluation to be conducted*: As an exploratory study, the goal was to evaluate the connection of badge requirements with NGSS scientific and engineering practices and the depth of knowledge intended and implemented in selected cases.
3. *Identify the stakeholders of the program*: Upstream stakeholders include the Boy Scouts of America who can improve their merit badge program. Downstream stakeholders include the youth who can learn about science/engineering through informal programs.
4. *Review or develop a program logic model for the program*: The logic of this program evaluation is that the badge requirements (determined by experts nationally) are implemented by adult volunteers with individual Scouts or groups of Scouts with an intended output of Boy Scouts who learn about science and engineering at a level deeper than memorization. This exploratory study will focus upon how the badge requirements are designed and implemented in select cases as reported by badge counselors.
5. *Identify dimensions to be investigated*: The link between the badge requirements and the NGSS scientific and engineering practices and Webb's DOK will be investigated. The reported implementation of these requirements by counselors will also be investigated.
6. *Determine evaluation methodology*: Document analysis will be used with the badge requirements and naturalistic inquiry will be used on questionnaire data gathered from adult volunteers who counsel these badges.
7. *Identify or develop instruments*: This is an exploratory study, so basic open-ended questionnaires were developed to send to badge counselors. Document analysis was conducted by comparing badge requirements to the NGSS documents on scientific and engineering practices and definitions for Webb's DOK levels.

8. *Collect data*: Questionnaires were sent out to all counselors in a specific Boy Scout counselor for these two badges. Requirements were downloaded from the national Boy Scout website.
9. *Analyze data for each dimension against rubrics*: This was done as described in the methodology section.
10. *Synthesize dimensional results and draw conclusions*: As an exploratory study, initial findings are reported, but future study is planned to expand upon these results.

METHODS

This exploratory case study (Yin, 2014) uses document analysis and questionnaires from one local Boy Scout council's merit badge counselors within a framework of program evaluation in order to use triangulation to assess to what extent the Environmental Science and Engineering merit badges can be tools to engage Boy Scouts in parts of the S&EP at depths of knowledge going beyond recall. The use of multiple data sources serves to provide richer detail about the case (Mathison, 1988; Stake, 2010). As an exploratory case study, one particular council was chosen because merit badge counselor contact information is stored locally. No claim for generalizability is made by this study. The document analysis provides a United States backdrop of expected outcomes while the questionnaire data allows for a localized picture of a Midwestern U.S. Boy Scout council's volunteer's methods.

Content analysis (Miller & Alvaradeo, 2005) of documents helps to understand a particular social practice, in this case, the practice of the Scouting movement creating a list of requirements that a boy must complete in order to be recognized with a merit badge. Content analysis involves identifying patterns, themes, and categories using several philosophical approaches (Patton, 2002). In this study, the authors use the S&EP progressions from Appendix F of the NGSS (NRC, 2013) to identify patterns of correlation between aspects of the grades 6-8 S&EP with the merit badge requirements. Grades 6-8 are used because the ages for Boy Scouts are ages 11-18. While high school youth are able to continue as Boy Scouts, the highest membership is at the middle school grades with attrition occurring as boys age and become active in other organizations, sports, or hobbies. Webb's Depth of Knowledge is then also used to categorize the requirements in terms of the depth required by the Scouts by the requirements. This document analysis gives a basis on which to analyze the intended outcome and methods of these two merit badges. The requirements for these two merit badges can be found in Tables 2 and 3.

Table 2
Engineering Merit Badge Requirements

1. Select a manufactured item in your home (such as a toy or an appliance) and, under adult supervision and with the approval of your counselor, investigate how and why it works as it does. Find out what sort of engineering activities were needed to create it. Discuss with your counselor what you learned and how you got the information.
2. Select an engineering achievement that has had a major impact on society. Using resources such as the Internet (with your parent's permission), books, and magazines, find out about the engineers who made this engineering feat possible, the special obstacles they had to overcome, and how this achievement has influenced the world today. Tell your counselor what you learned.
3. Explain the work of six types of engineers. Pick two of the six and explain how their work is related.
4. Visit with an engineer (who may be your counselor or parent) and do the following:
    a. Discuss the work this engineer does and the tools the engineer uses.
    b. Discuss with the engineer a current project and the engineer's particular role in it.
    c. Find out how the engineer's work is done and how results are achieved.
    d. Ask to see the reports that the engineer writes concerning the project.
    e. Discuss with your counselor what you learned about engineering from this visit.
5. Do ONE of the following:
    a. Use the systems engineering approach to make step-by-step plans for your next campout. List alternative ideas for such items as program schedule, campsites, transportation, and costs. Tell why you made the choices you did and what improvements were made.
    b. Make an original design for a piece of patrol equipment. Use the systems engineering approach to help you decide how it should work and look. Draw plans for it. Show the plans to your counselor, explain why you designed it the way you did, and explain how you would make it.
6. Do TWO of the following:
    a. Transforming motion. Using common materials or a construction set, make a simple model that will demonstrate motion. Explain how the model uses basic mechanical elements like levers and inclined planes to demonstrate motion. Describe an example where this mechanism is used in a real product.

b. Using electricity. Make a list of 10 electrical appliances in your home. Find out approximately how much electricity each uses in one month. Learn how to find out the amount and cost of electricity used in your home during periods of light and heavy use. List five ways to conserve electricity.
c. Understanding electronics. Using an electronic device such as a mobile telephone or portable digital media player, find out how sound travels from one location to another. Explain how the device was designed for ease of use, function, and durability.
d. Using materials. Do experiments to show the differences in strength and heat conductivity in wood, metal, and plastic. Discuss with your counselor what you have learned.
e. Converting energy. Do an experiment to show how mechanical, heat, chemical, solar, and/or electrical energy may be converted from one or more types of energy to another. Explain your results. Describe to your counselor what energy is and how energy is converted and used in your surroundings.
f. Moving people. Find out the different ways people in your community get to work. Make a study of traffic flow (number of vehicles and relative speed) in both heavy and light traffic periods. Discuss with your counselor what might be improved to make it easier for people in your community to get where they need to go.
g. Building an engineering project. Enter a project in a science or engineering fair or similar competition. (This requirement may be met by participation on an engineering competition project team.) Discuss with your counselor what your project demonstrates, the kinds of questions visitors to the fair asked, and how well you were able to answer their questions.

7. Explain what it means to be a registered Professional Engineer (P.E.). Name the types of engineering work for which registration is most important.
8. Study the Engineer's Code of Ethics. Explain how it is like the Scout Oath and Scout Law.
9. Find out about three career opportunities in engineering. Pick one and research the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

Table 3

Environmental Science Merit Badge Requirements

1. Make a timeline of the history of environmental science in America. Identify the contribution made by the Boy Scouts of America to environmental science. Include dates, names of people or organizations, and important events.
2. Define the following terms: population, community, ecosystem, biosphere, symbiosis, niche, habitat, conservation, threatened species, endangered species, extinction, pollution prevention, brownfield, ozone, watershed, airshed, nonpoint source, hybrid vehicle, fuel cell.
3. Do ONE activity from EACH of the following categories (using the activities in this pamphlet as the basis for planning and projects):
   A. Ecology
      (1) Conduct an experiment to find out how living things respond to changes in their environments. Discuss your observations with your counselor.
      (2) Conduct an experiment illustrating the greenhouse effect. Keep a journal of your data and observations. Discuss your conclusions with your counselor.
      (3) Discuss what is an ecosystem. Tell how it is maintained in nature and how it survives.
   B. Air Pollution
      (1) Perform an experiment to test for particulates that contribute to air pollution. Discuss your findings with your counselor.
      (2) Record the trips taken, mileage, and fuel consumption of a family car for seven days, and calculate how many miles per gallon the car gets. Determine whether any trips could have been combined ("chained") rather than taken out and back. Using the idea of trip chaining, determine how many miles and gallons of gas could have been saved in those seven days.
      (3) Explain what is acid rain. In your explanation, tell how it affects plants and the environment and the steps society can take to help reduce its effects.
   C. Water Pollution
      (1) Conduct an experiment to show how living things react to thermal pollution. Discuss your observations with your counselor.
      (2) Conduct an experiment to identify the methods that could be used to mediate (reduce) the effects of an oil spill on waterfowl. Discuss your results with your counselor.
      (3) Describe the impact of a waterborne pollutant on an aquatic community. Write a 100-word report on how

that pollutant affected aquatic life, what the effect was, and whether the effect is linked to biomagnification.

D. Land Pollution

(1) Conduct an experiment to illustrate soil erosion by water. Take photographs or make a drawing of the soil before and after your experiment, and make a poster showing your results. Present your poster to your counselor.

(2) Perform an experiment to determine the effect of an oil spill on land. Discuss your conclusions with your counselor.

(3) Photograph an area affected by erosion. Share your photographs with your counselor and discuss why the area has eroded and what might be done to help alleviate the erosion.

E. Endangered Species

(1) Do research on one endangered species found in your state. Find out what its natural habitat is, why it is endangered, what is being done to preserve it, and how many individual organisms are left in the wild. Prepare a 100-word report about the organism, including a drawing. Present your report to your patrol or troop.

(2) Do research on one species that was endangered or threatened but which has now recovered. Find out how the organism recovered, and what its new status is. Write a 100-word report on the species and discuss it with your counselor.

(3) With your parent's and counselor's approval, work with a natural resource professional to identify two projects that have been approved to improve the habitat for a threatened or endangered species in your area. Visit the site of one of these projects and report on what you saw.

F. Pollution Prevention, Resource Recovery, and Conservation

(1) Look around your home and determine 10 ways your family can help reduce pollution. Practice at least two of these methods for seven days and discuss with your counselor what you have learned.

(2) Determine 10 ways to conserve resources or use resources more efficiently in your home, at school, or at camp. Practice at least two of these methods for seven days and discuss with your counselor what you have learned.

(3) Perform an experiment on packaging materials to find out which ones are biodegradable. Discuss your conclusion with your counselor.

G. Pollination

(1) Using photographs or illustrations, point out the differences between a drone and a worker bee. Discuss the stages of bee development (eggs, larvae, pupae). Explain the pollination process, and what propolis is and how it is used by honey bees. Tell how bees make honey and beeswax, and how both are harvested. Explain the part played in the life of the hive by the queen, the drones, and the workers.

(2) Present to your counselor a one-page report on how and why honey bees are used in pollinating food crops. In your report, discuss the problems faced by the bee population today, and the impact to humanity if there were no pollinators. Share your report with your troop or patrol, your class at school, or another group approved by your counselor.

(3) Hive a swarm OR divide at least one colony of honey bees. Explain how a hive is constructed.

4. Choose two outdoor study areas that are very different from one another (e.g., hilltop vs. bottom of a hill; field vs. forest; swamp vs. dry land). For BOTH study areas, do ONE of the following:

   A. Mark off a plot of 4 square yards in each study area, and count the number of species found there. Estimate how much space is occupied by each plant species and the type and number of nonplant species you find. Write a report that adequately discusses the biodiversity and population density of these study areas. Discuss your report with your counselor.

   B. Make at least three visits to each of the two study areas (for a total of six visits), staying for at least 20 minutes each time, to observe the living and nonliving parts of the ecosystem. Space each visit far enough apart that there are readily apparent differences in the observations. Keep a journal that includes the differences you observe. Then, write a short report that adequately addresses your observations, including how the differences of the study areas might relate to the differences noted, and discuss this with your counselor.

5. Using the construction project provided or a plan you create on your own, identify the items that would need to be included in an environmental impact statement for the project planned.

6. Find out about three career opportunities in environmental science. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

Questionnaire data is then used to analyze these requirements from the perspective of the requirements "in action" as reported by badge counselors. Questionnaires were emailed to all registered Environmental Science and Engineering merit badge counselors in a local Boy Scout council (a region chartered by the national office to lead the Boy Scout programs in a specific geographic area). The questionnaires are reproduced in Tables 4 and 5. Responses to these questionnaires were analyzed by comparing the answers to the categories of the S&EP that were coded for the various merit badge requirements to determine to what extent these counselors may have engaged Boy Scouts with portions of the S&EP. The answers were compared to the classification of requirements by the lead author to determine whether there was evidence of a requirement's link to the S&EP being implemented by counselors. The second author reviewed the analysis.

Table 4
Engineering Merit Badge Counselor Questionnaire

1. What is your background in engineering?

Questions 2-4 refer to Requirement 1.

2. What types of objects have you used for requirement 1?
3. Explain your how you go about guiding scouts to investigate how and why the object works?
4. When you have a discussion, do you discuss individually with Scouts or as a group? What does your discussion look/sound like? For instance, what types of questions do you ask?

Questions 5-8 ask about Requirement 5.

5. Which requirement (a or b) have you worked with Scouts on?
6. How closely do you follow the systems engineering approach explained in the merit badge pamphlet? (Establish a systems engineering operation, describe the project requirements, plan the project's activities with time schedules, conduct research-get ideas, develop the best ideas for alternative solutions, analyze the best ideas, perform the construction or solution of the project, check the solution). Please explain how you do or why you do not.
7. How do you emphasize the engineering concept of criteria (what are the requirements for designed solution?)
8. How do you emphasize the engineering concept of constraints of material, cost, and time as related to the designed solution?

Questions 9-12 refer to Requirement 6.

9. For Requirement 6, which of the requirements have you worked with Scouts on?
10. Do you have Scouts follow the steps for the investigations in the merit badge book? Do Scouts ever modify those steps? If so, how?
11. Do Scouts ever collect quantitative data for these investigations?
    If so, what are some examples?
12. Do Scouts ever design their own solutions for any of the requirements for number 6? If they do, how do you guide them? How independently do they work?
13. Are there any other comments about what you feel is important in terms of counseling engineering merit badge that you would like to share?

Table 5

Environmental Science Merit Badge Counselor Questionnaire

1. What is your own background with environmental science?
2. Please indicate which of the following options you use with Scouts earning the merit badge: (Require 3 options listed)
3. For any of the experiments conducted, do the Scouts follow the directions in the merit badge book? Do they ever change that procedure? If they do, please explain how/give an example.
4. When you have the Scouts discuss their conclusions or observations with you, what is your goal? What types of questions (if any) do you use? Do you ever require them to refer back to the experiments?
5. When doing any experiments, do the Scouts have to construct their own explanations to explain the environmental science principles? Do they do this individually or as a group? How do they use any numerical data from the experiments? How do they use any descriptive data from the experiments?
6. For the outdoor study area (requirement 4), how do you have the Scouts estimate the space occupied by each plant species?
7. Are there any other comments about what you feel is important in terms of counseling environmental science merit badge that you would like to share?

ANALYSIS

Engineering

The Engineering merit badge requirements were found to align with portions of S&EP 2, 3, 4, 5, 6, and 8. Two Engineering merit badge counselors responded to the questionnaire (out of 54 potential emails provided). One, pseudonym "Linda", is a civil engineer licensed as a Professional Engineer in 7 states and who works as a structural engineer in water and wastewater industries. She was also named as an inventor on five U.S. patents. The other, pseudonym Fred, is a professional traffic operations engineer in three states. He has worked as a construction, planning, and design engineer on transportation projects (small intersections to large system interchanges), ports, railroad, and transit facilities.

Three of the requirements related to S&EP 3 "planning and carrying out investigations." The element "Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation" was addressed by requirements 1 and 6a. Requirement 1 has the Scout investigate how and why a household item works in terms of engineering concepts; this links directly with the element's language. Fred buys small kitchen appliances at a thrift store and allows them to take the items apart to "see the components and how they work together as a system to do whatever the function of the appliance is." Fred conducts a group discussion afterwards with questions such as "How is it powered? What electric and electronic components are in it? How do the different gears work together? Why are they different sizes? What types of engineers work on each of these things?" Linda has used toasters, VCRs, portable electric mixers, clock radios, vacuums, and fish reels from thrift stores. She groups Scouts into groups of 3-4 and requires each Scout to take a part in the disassembly. She asks them to think about the parts in terms of questions such as "Why is that metal and not plastic? Why was that connected to...?"

Requirement 6a is an option (Requirement 6 gives seven options of which a Scout is to choose two) to use common materials to make a simple model to demonstrate motion. The merit badge pamphlet gives suggestions for how to use simple machines with a suggested project of transporting a 10 kilogram object up a slope at least 2 meters long and 1 meter high and then stop. Although the criteria for success are suggested, the process is open-ended. A second element of S&EP 3 was "Collect data about the performance of a proposed object, tool, process or system under a range of conditions." Requirement 6d asks a Scout to "do experiments to show the differences in strength and heat conductivity in wood, metal, and plastic." Sample experiments are given in the merit badge pamphlet, so experimental design is not required (but also not forbidden). Instead, Scouts are to focus on data collection to draw conclusions. For instance, it suggests dropping a metal tablespoon, a piece of wood, and a piece of plastic into boiling water for one minute. Scouts are then to touch each (carefully) to the back of their hand and record qualitative observations.

One requirement related to S&EP 4 "analyzing and interpreting data". Requirement 6e involves doing an experiment showing how energy can be converted from one form to another. An experiment on measuring the temperature change of water in a pie tin under the sun versus a cloudy day was suggested by the pamphlet, so the focus was not so much on the investigation itself but on the interpretation of the results. This correlated with the progression element "Analyze and interpret data to provide evidence for phenomena."

Requirements 6b and 6f offer the possibility of connecting with S&EP 5 "using mathematics and computational thinking" under the element of "Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems." 6b has Scouts find out approximately how much electricity 10 home appliances use in a month as well as the cost of light and heavy use of electricity in their homes. This could involve the use of math, or possibly just data collection that is automated. 6f involves a study of traffic flow during heavy and light periods. This has the potential for mathematical connections. Fred reported that "We do this as a group exercise and normally provide the data they need." Linda did not report using data. This suggests that S&EP 5 is probably not a normal outcome for Boy Scout youth earning this merit badge.

Three requirements were coded under S&EP 6 "constructing explanations and designing solutions" with the element "Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints." Requirement 6g is an open ended requirement to enter a project in a science or engineering fair. Engineering fair projects likely require the use of a design cycle.

Requirements 5a and 5b are options (Scouts must choose one of them) that both involve using a systems engineering approach to either plan for the next campout or design a piece of equipment. These requirements fit very well with the concept of an engineering design cycle. They are required to develop the best ideas for alternative solutions, analyze the best ideas, and then select the best idea. This offers an opportunity connect to the concepts of design criteria and constraints.

Linda remarked that "The material in the MB booklet on systems engineering is oddly presented and I wonder what the source of the book's material is. However, I let the scouts choose their option. Most choose (b)." She stated that she uses the systems approach in the book with modifications because "If one had unlimited money [the book's method] would be great. If one did not have marketing types selling a product before its design is complete that would help too." She then explained that in a discussion with Scouts led to her disclosure of her work on one of the patents on which she is named. She emphasized the concept of criteria as "the best way to do this is to find a problem to solve, or a chore to make easier or safer or both." She asks the Scouts what problems they hope to solve with their design and directs them to discuss the materials they plan to use and the effects of the environment on those materials. In terms of constraints, she states that they often don't "have a solid idea about material costs and properties this sometimes becomes a teaching moment".

Fred requires Scouts to complete either option 5a or 5b before meeting with him. He states then when they present their plans, some "read the book and present in a way that shows they considered the system." In terms of criteria, he asks about the "purpose of their project and how they accomplish the needed outcome." In terms of constraints, Fred asks materials, cost, and time if they didn't discuss them without prompting. He also stated that "if the scout did not consider the system or engineering methods of designing a project, we make them think about it and discuss how they would change their project with these things in mind."

Finally, three of the requirements were linked with S&EP 8 "obtaining, evaluating, and communicating information." Requirements 1 and 4e could possibly relate to the element "Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations" since they require a discussion between the Scout and the counselor about what they learned (investigating how an item works for requirement 1 and interviewing an engineer for all of the parts of requirement 4). Requirement 2 could relate to the element "Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence." Scouts are required to research an engineering achievement, although the requirement does not require multiple sources. Of the practices discussed, the connections to S&EP 8 is the most tentative, even based solely on document analysis.

When the Engineering merit badge requirements are analyzed for the level of Webb's Depth of Knowledge (DOK) associate with each, the most common association was with level 2 (understanding/skills) since they involve following set procedures at a competent level. This related to requirements 1,2,3,6a-f, and 7 (see Table 6). Two requirements were coded at level 3 (strategic thinking). Requirement 4e required drawing original conclusions about an interview with an engineer. Requirement 8 asks a Scout to compare the Engineer's Code of Ethics with the Scout Oath and Law (comparison). Finally, requirements 5a and 5b (of which a Scout selects one) both involve level 4 (extended thinking) because the Scout is given an original task to use the systems engineering approach.

Table 6
Engineering Merit Badge Scientific & Engineering Practice/Webb's Depth of Knowledge Correlation

Requirement	S&EP	Progression Element	DOK
1	3	2	4
	8	5	2
2	8	3	2
3	-	-	2
4a-d	-	-	-
4e	8	5	3
5a	6	7	4
5b	6	7	4
6a	2	5	2
	3	2	2
6b	5	4	2
6c	-	-	2
6d	3	5	2
6e	4	4	2
6f	5	4	2
6g	6	7	4
7	-	-	2
8	-	-	3
9	-	-	-

Environmental Science

The Environmental Science merit badge best connects with the S&EP in requirements 3 and 4. Requirement 3 has seven subsections which offer three choices for Scouts of which they pick one. It should be noted that for sections A, B, and C (ecology, air pollution, and water pollution) option 3 for each one allows Scouts to avoid conducting an investigation and to read and recall information through discussion or writing a report. Five merit badge counselors responded (62 email addresses supplied.) Using pseudonyms, their backgrounds were as follows. Michael has a hobbyist's interest in environmental science and has taken college science courses. Simon is a college student interested in biology and natural science who recently changed his major to a natural science field. Aaron sets up control systems, regulatory reporting, and asset management software for water, wastewater, landfill and electric utilities. Veronica works as a conservation specialist with soil and water. Finally, Bradley has a bachelor's degree in Engineering Geology and a master's degree in civil engineering. He has worked 34 years in the hydrogeology profession.

Planning and carrying out investigations (S&EP 3) was related to eight of the optional requirements: 3A-1,3A-2,3B-1,3C-1,3C-2,3D-1,3D-2, and 3F-3. Each of these requirements involve Scouts conducting an investigation as specified in the merit badge pamphlet. A procedure is provided for the Scouts to follow as well as discussion questions. While the Scouts are not creating their own plans for an investigation, they are still meeting the element of S&EP 3: "Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation." The Scouts still collect data as evidence to guide their discussions about topics such as acid rain, global warming, air pollution, and oil spills. Of the five counselors who responded to the questionnaire, Bradley showed the most flexibility by stating that he had worked with Scouts on virtually all of the options for these requirements. Otherwise, many of the counselors reported that they had only worked with Scouts on the options for these requirements that did not involve conducting experiments or investigations. For ecology, one reported using 3A-1, the other 3 stated that they opted for the discussion oriented 3A-3. For air pollution, only Bradley said he had conducted the experiment (3B-1) with Scouts, the others opted for the gas usage calculations or discussion on acid rain. For water pollution, two marked conducting an observation (3C-1) and three the discussion requirement (3C-3). For land pollution, Bradley marked all three, 2 marked an experiment (3D-1) and two the photography activity (which does require more than just discussion). For pollution prevention, resource recovery, and conservation, two worked with Scouts on the experiment (3F-3) while 3 focused on the other two options that were problem solving oriented, but not investigations. When asked about whether they follow the lab directions as presented in the book, three indicated that they do not, but Veronica reported that "We do the soil erosion trays, but they are built differently and we collect the water and use a turbidity tube to know for certain which sample has more sediment in it. We also change up the middle try—use different mulches and covers." She appears to be using her professional training while still engaging Scouts in a similar directed investigation experience.

Two of the requirements may relate to S&EP 5 "using mathematics and computational thinking" depending on the support given by a counselor for having the Scouts "apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems." Requirement 3B-2 asks Scouts to record trips taken, mileage, and fuel consumption for seven days and to calculate how many miles per gallon the car gets. They then apply the concept of trip chaining to calculate the savings in miles and gallons. In requirement 4A estimate the number of space occupied by different plant species in two study plots. When asked about how they might use mathematical concepts, Simon said that Scouts record "more general information" like the type of tree, time of day, species, etc. rather than anything quantitative. Veronica has them use tape measures to estimate the number of species. Bradley has them "plot species on grid paper (X, Y coordinates) with symbols representing plant species" and then has them "count squares for population density." Bradley's response indicates that there is potential for S&EP 5 to be addressed by this merit badge, but he is a highly trained scientist/engineer with 34 years of professional experience.

Nine of the requirements relate to S&EP 6 "constructing explanations and designing solutions" under the element "Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena." Eight of these nine also were coded for S&EP 3 for carrying out investigations. The Scouts are also asked to discuss their observations/findings with their counselor for each of these investigations. This is in alignment with the vision of the NGSS in that the investigations are not seen as ends unto themselves. Scouts are asked to make inferences and draw conclusions using the data they observed or collected. Michael has them write up their results in an "understandable format." Veronica notes that many of their responses trying to tie explanations to the experimental data show "regurgitation" and that her goal is "if the information going in is technical, I look for the information coming out to be in their own words". Bradley states that he does look for simple data tables and graphs. Simon did not use any of the experimental requirements. Requirement 4A about the study plots is also connected with this practice because Scouts are asked to write a report (and discuss it with the counselor) about how the concepts of biodiversity and population density relate to their observations in their study plots.

Finally, two requirements were connected to S&EP 8 "obtaining, evaluating, and communicating information" with the element "Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. Requirement 3E relates to endangered species. Options 1 and 2 both require doing research either on an endangered species in a Scout's state or a formally endangered species that is now recovered. They are to write a report and discuss it with their counselor.

Using the lens of Webb's Depth of Knowledge, four requirements were rated at the level of recall, fifteen at level 2 for understanding/skills, and five at the third level of strategic thinking (see Table 7). No extended thinking projects were rated. Two of the recall requirements were about vocabulary and a timeline of environmental science history in America. As noted earlier, two options for 3A and 3B only required a report that was at the recall level. The vast majority of the requirement options involved following the procedures for investigations given in the merit badge pamphlet, but following this up with discussion about the meaning of the results with a counselor. The examples of strategic thinking were in several of the investigation options. Requirement 3B-2 involving the tracking of mileage and gas usage in a car and then determining how trip chaining would affect this result was a strong example of this level. Requirement 3D-3 on land pollution has Scouts photograph an area affected by erosion and discuss what can be done to alleviate erosion. This has the potential of originality if the Scout is given freedom to choose their own photograph site by a counselor. Requirements 3F-1 and 3F-2 on pollution prevention, resources recovery, and conservation both require Scouts to put into practice methods of conservation or pollution reduction and to reflect on them. Requirement 4B is another option when studying two study plots by making at least three visits for 20 minutes at a time to make observations. An original journal is kept and a report on a Scout's observations is required to then be discussed with the counselor. The Scout is given freedom to create an original project with this requirement.

DISCUSSION

This study on two of the Boy Scouts of America's STEM based merit badges, Environmental Science and Engineering, shows that there are indeed both designed and implemented connections to the Scientific and Engineering Practices of the NGSS. This is important because it shows that the vision of three dimensional learning espoused by the NGSS (scientific and engineering practices, disciplinary core ideas, and crosscutting concepts addressed in all units of study) is possible and happening in the non-formal/informal educational world as well as in classrooms. This study focused specifically on the scientific and engineering practices, but the merit badge requirements clearly have a focus on scientific disciplinary core ideas such as LS2: Ecosystems: Interaction, Energy, and Dynamics for Environmental Science merit badge and ETS: Engineering Design for Engineering merit badge. Similarly, the crosscutting concepts of patterns in nature as well as cause and effect connect strongly with much of Environmental Science merit badge through the investigations conducted or research required. The Engineering merit badge connects strongly with structure and function for many of the mechanical projects and systems and system models for the systems engineer problem.

Questionnaire responses for merit badge counselors indicate that people with a wide variety of backgrounds volunteer to counsel these badges. This may be especially true for the Environmental Science merit badge since it is one of two options (the other being Sustainability) required to earn Eagle Scout which seems to motivate adults to volunteer so that Scouts in their troop have access to earning this badge. In fact, one volunteer responded to the questionnaire stating that "I have never actually conducted a full session of this badge … my troop committee asked me to register as a counselor for the badge in case one of the troop scouts was unable to finish the badge at camp." Nevertheless, various highly qualified scientists and engineers have volunteered to counsel both this and Engineering merit badges.

Engineering merit badge appeared to be designed in a manner more aligned to the S&EP of the NGSS in that Scouts were required to investigate how an item worked and to use engineering design processes at several points. Environmental Science merit badge has the ability to become a learning experience that does not require investigation, interpretation, or analysis other than the field study. However, one respondent's answers implied that even for this requirement the Scouts were not engaged in any scientific and engineering practices appropriate at the middle school level or higher.

Table 7
Environmental Science Merit Badge Scientific & Engineering Practice/Webb's Depth of Knowledge Correlation

Requirement	S&EP	Progression Element	DOK
1	-	-	1
2	-	-	1
3A-1	6	1	2
	3	2	
3A-2	6	1	2
	3	2	
3A-3	-	-	1
3B-1	6	1	2
	3	2	-
3B-2	5	4	3
3B-3	-	-	1
3C-1	6	1	2
	3	2	-
3C-2	6	1	2
	3	2	-
3C-3	-	-	-
3D-1	6	1	2
	3	2	
3D-2	6	1	2
	3	2	
3D-3	-	-	3
3E-1	8	5	2
3E-2	8	5	2
3E-3	-	-	2
3F-1	-	-	3
3F-2	-	-	3
3F-3	6	1	2
	3	2	
3G-1	-	-	2
3G-2	-	-	2
3G-3	-	-	2
4A	6	1	2
	5	4	
4B	-	-	3
5	-	-	-
6	-	-	-

In as much as the Boy Scouts of America rely on volunteers to serve as merit badge counselors, it could behoove them to develop brief and succinct supporting materials for their STEM based merit badges that could inform merit badge counselors about how to connect the requirements to the scientific and engineering practices of the NGSS. This should not be done solely as a standards alignment exercise as that is doubtful in terms of persuasiveness toward a volunteer counselor. Rather, these counselors, who likely have strong professional or avocational backgrounds in science or engineering, may be able to realize some of the vision of the NGSS that science and engineering are not just bodies of facts for Scouts (or any student) to master; rather, they are fields of inquiry with many different practices that scientists and engineers engage in so that they can find answers to questions and solve problems. As one of the purposes of the merit badge program is to provide opportunities for Scouts to explore careers, the purposeful focus on scientific and engineering practices would advance this goal.

In particular, practices 3, 6, and 8 would be fairly straightforward for the Boy Scouts of America to emphasize in these merit badges. Currently the merit badge pamphlets offer much support in terms of giving procedures for investigations. They could be revised in the future to also give support for Scouts to design their own procedures to solve age appropriate questions related to science. For the engineering designs, the requirements could be revised so that Scouts would not only consider alternatives, chose one, and build it, but they could then be required to analyze their results, revise, and reconstruct another iteration of their design.

A focus on Webb's Depth of Knowledge could also deepen the learning from STEM merit badges. This study does not call on the Boy Scouts to make all requirements at level 4, for that would be inappropriate. Currently, there is a decent mix of different levels of DOK, which is good. Requirements could be revised so that there is a bit more emphasis on levels 3 and 4 by requiring more original thinking and planning by the Scouts during investigations or design processes as well as having to consider alternative explanations and designs.

CONCLUSION

Environmental Science and Engineering merit badges have requirements that are written in a manner to engage Boy Scouts in several of the scientific and engineering practices that adult scientists and engineers use. The requirements calling for investigations are often supported by pre-written procedures, but several requirements do call for Scouts to do their own original investigative design and interpretation of results. It would behoove the Boy Scouts and other non-formal science education programs to design their merit badges in a manner that does not let Scouts or adult volunteers completely avoid investigations and data interpretation. Learning by discussion could lead to an understanding of science as a body of facts to be mastered rather than a field of study with debate and interpretation of data. Nevertheless, these merit badges serve as a strong example of the possibilities for three-dimensional learning promoted by the vision of the Next Generation Science Standards in the non-formal educational realm.

Future research into the actual learning of youth through Scouting's badging programs would fill an important gap in the research base. The effectiveness of informal badging programs is not well studied. This project begins that exploration by analyzing the connections between the designed informal curriculum to current ideas in science and engineering education. Other future research should also focus upon observing the counseling sessions to compare the implementation with the reported implementation by counselors.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Dr. Matthew E. Vick is an associate professor in the Department of Curriculum and Instruction at the University of Wisconsin-Whitewater, USA. Dr. Michael P. Garvey is a superintendent of schools in Johnson Creek, WI, USA. Both have served as volunteers with the Boy Scouts of America.

References

Allen, S., Gutwill, J., Perry, D. L., Garibay, C., Ellenbogen, K. M., Heimlich, J. E., Reich, C.A., & Klein, C. (2007). Research in Museums: Coping with complexity. In J. H. Falk, L. D. Dierking, & S. Foutz (Eds.) In principle, in practice: Museums as learning institutions (pp. 229–245), Lanham, MD: AltaMira Press.

Bang, M., & Medin, D. (2010). Cultural processes in science education: Supporting the navigation of multiple epistemologies. Science Education, 94(6), 1008–1026.

Bouzo, S. (2012). Engaging underserved audiences in informal science education through community-based partnerships (master's thesis). Retrieved from Colorado State University, Fort Collins, CO. https://dspace.library.colostate.edu/handle/10217/71618

Boy Scouts of America (BSA). (2013). Merit badge counselor information. Retrieved from http://www.scouting.org/filestore/pdf/34405.pdf

Chyung, S.Y. Wisniewski, A., Inderbitzen, B., & Campbell, D. (2013). Performance Improvement Quarterly, 26(3), 87-115.

Davidson, E.J. (2005). Evaluation methodology basics: The nuts and bolts of sound evaluation. Thousand Oaks, CA: SAGE.

Falk, J. H., & Dierking, L. D. (2000). Learning from museums: The visitor experience and the making of meaning. Walnut Creek, CA: AltaMira Press.

Falk, J. H., Scott, C., Dierking, L., Rennie, L., & Jones, M. C. (2004). Interactives and visitor learning. Curator: The Museum Journal, 47(2), 171–198.

Ferreira, M. (2001). The effect of an after-school program addressing the gender and minority achievement gaps in science, mathematics, and engineering. Arlington, VA: Educational Research Spectrum, Educational Research Services.

Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. Studies in Science Education, 28, 87–112.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. International Journal of Science Education, 33(1), 27–50.

Jan, S.J., Johnson, B.R., & Kim, Y. (2012). Eagle Scouts: Merit Beyond the Badge. Waco, TX: Baylor University. Retrieved from http://www.baylorisr.org/wp-content/uploads/Boy-Scouts-Report.pdf

Jarman, R. (2005). Science learning through scouting: an understudied context for informal science education. International Journal of Science Education, 27(4), 427-450.

Jolly, E., Campbell, P., & Perlman, L. (2004). Engagement, capacity, continuity: A trilogy for student success. St. Paul, MN: GE Foundation and Science Museum of Minnesota.

Martin, L. M. (2004). An emerging research framework for studying informal learning and schools. Science Education, 88(Suppl. 1), S71–S82.

Mathison, S. (1988). Why triangulate? Educational Researcher, 17(2), 13-17.

Miller, F.A. & Alvarado, K. (2005). Incorporating documents into qualitative nursing research. Journal of Nursing Scholarship, 37(4):348-353.

National Research Council. Committee on Learning Science in Informal Environments. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, Editors. Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. (2009). Learning Science in Informal Environments: People, Places, and Pursuits. Washington, DC: The National Academies Press.

National Research Council. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and

Education. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press.

NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

Patton, M.Q. (2002). Qualitative research & evaluation methods (3rd ed.). Thousand Oaks, CA: Sage.

Polson, E. C., Kim, Y., Jang, S. J., Johnson, B. R., & Smith, B. (2013). Being prepared and staying connected: Scouting's influence on social capital and community involvement. Social Science Quarterly, 94(3), 758-776.

Rahm, J., & Ash, D. (2008). Learning environments at the margin: Case studies of disenfranchised youth doing science in an aquarium and an after-school program. Learning Environments Research, 11, 49-62.

Ramey-Gassert, L., Walberg, H., & Walberg, H. (1994). Reexamining connections: Museums as science learning environments. Science Education, 78(4), 345–363.

Renninger, A., Hidi, S., & Krapp, A. (2014). The role of interest in learning and development. New York: Psychology Press.

Rennie, L. J., & McClafferty, T. P. (2002). Objects and learning: Understanding young children's interaction with science exhibits. In S. G. Paris (Ed.), Perspectives on object-centered learning in museums (pp.191–213). Mahwah, NJ: Lawrence Erlbaum Associates.

Riedinger, K. (2015). Identity development of youth during participation at an informal science education camp. International Journal of Environmental and Science Education, 10(3), 453-475.

Sample McMeeking, L. B., Weinberg, A. E., Boyd, K. J. and Balgopal, M. M. (2016), Student Perceptions of interest, learning, and engagement from an informal traveling science museum. School Science and Mathematics, 116: 253–264. doi:10.1111/ssm.12176

Scriven, M. (2007). Key evaluation checklist. Retrieved from www.wmich.edu/evalctr/archive_checklists/kec_feb07.pdf

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. The Journal of Educational Research, 95(6), 323–332.

Stake, R. E. (2010). Qualitative research: Studying how things work. New York, NY: The Guilford Press

Tai, R.H., Liu, C.Q., Maltese, A.V., & Fan, X. (2006). Planning early for careers in science. Science, 312(5777), 1143-1144.

Tran, N. A. (2011). The relationship between students' connections to out-of-school experiences and factors associated with science learning. International Journal of Science Education, 33(12), 1625–1651.

Webb, N. (1997). Research Monograph Number 6: Criteria for alignment of expectations and assessments on mathematics and science education. Washington, D.C.: CCSSO.

Webb, N. (August 1999). Research Monograph No. 18: Alignment of science and mathematics standards and assessments in four states. Washington, D.C.: CCSSO.

Yin, R. K. (2014). Case study research: Design and methods (5th ed.). Thousand Oaks, CA: Sage.