Journal of Extension
www.joe.org

February 2014
Volume 52
Number 1
Article # 1RIB5

Student Interest in STEM Disciplines: Results from a Summer Day Camp

Abstract

Research shows student participation in science programming can affect scientific interest, academic performance, college majors, and careers. This article reports a study where results obtained from questionnaires completed by participants, parents, and guardians assessed whether interest in STEM disciplines was advanced by a summer day-camp attended by elementary and middle school students. Participants indicated that most activities positively affected their interest in STEM subjects. Parents and guardians also reported that student subject-matter interest was noticeably enhanced following the camp. Results indicate that inquiry-based but non-mathematical STEM activities were most successful at stimulating interest.

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Introduction

In August 2012, a county 4-H club hosted a summer STEM (science, technology, engineering, and math) day camp for local elementary and middle school students. The 3-day camp was advertised as appropriate for students entering 3rd-6th grades fall semester 2012. Students in these grade levels are beginning their exposure to some of the more complex processes inherent in scientific study (e.g., experimentation and scientific method). Given the topic complexity, camp organizers purposefully selected age-appropriate activities that required engagement and reflection, but were also fun, hands-on, and purposeful. Activities that would stimulate interest and enhance learning were chosen, consistent with recommendations from Blair et al. (2004).

The goal of the camp was to promote interest in STEM disciplines by student participation in experiential STEM activities. Experiential learning occurred through direct engagement with the subject matter, interaction with others, and detailed observation. Of the nine total experiential activities, six were inquiry-based, and three were not. Engagement in inquiry-based learning activities required students to identify relevant information, individually and collectively problem-solve, anticipate results, and apply findings.

These types of non-formal educational programs are relevant because they can effectively promote scientific interest, and students who demonstrate an interest in science are more likely to study science in college and choose a scientific career. Gibson and Chase (2002) found that middle school students who participated in a science camp reported increased interest in science relative to peers who did not participate. Markowitz (2002) found that many high school students who participated in a summer science program showed increased improvement in science performance and indicated an enhanced interest in pursuing a career in science. Additionally, according to Markowitz, many of the program participants who developed an interest in science went on to select a science major in college.

While research suggests inquiry-based learning benefits learners studying science, it remains unclear exactly what does, and does not, constitute inquiry-based learning. For example, experiential learning, active learning, problem-based learning, hands-on-science, and other descriptors all refer to approaches for learning science (and other subjects) that involve direct engagement with the subject matter. However, not all these terms are synonymous with inquiry-based learning. Furthermore, while inquiry-based learning is experiential, not all experiential learning is inquiry-based. For educators interested in enhancing scientific interest among students, these differences are important. This article provides useful descriptions of inquiry-based learning.

Inquiry-Based Learning

Consistent with Albright, Petrulis, Vasconcelos, and Wood (2012), the study reported here characterized inquiry-based learning as a student-centered, problem-solving process where inquiry or research guides student learning. Inquiry-based learners are active learners who take responsibility for their learning and engage directly with the subject matter (Jansen, 2011). With inquiry-based learning, students actively participate in knowledge construction by addressing germane problems that evolve from personal experience and observation (Education Development Center, Inc., 2012). Addressing issues that are meaningful to the learner helps facilitate adoption of the perspectives and attitudes that promote a context of inquiry (Bourdeau, 2004). Inquiry-based learning encourages students to develop questions about their world and to solve real problems (Smith & Enfield, 2002; Zeek, 2011).

Inquiry-Based Learning and Science

A growing body of evidence suggests inquiry-based learning is an effective approach for students studying science (Blair et al., 2004; Bourdeau, 2004; Clarke, 2010; Ireland, Watters, Brownlee, & Lupton, 2012; Skelton, Seevers, Dormody, & Hodnett, 2012; Smith, Meehan, Enfield, George, & Young, 2004; Wu & Wu, 2011). Encouraging students to directly engage with the subject matter by asking questions, developing hypothesis, and conducting experiments helps promote scientific understanding (Skelton et al., 2012). According to Clarke (2010), students studying science who are exposed to inquiry-based learning develop process skills enabling them to think like scientists. Inquiry-based learning, with its emphasis on experience, questioning, searching for evidence, analysis, interpretation, and communication of results (explanation), has particular value for future scientists because it exposes them to skills utilized in their careers (Skelton et al., 2012).

Purpose

The purpose of the study reported here was an attempt to corroborate other studies that have shown a relationship between participation in inquiry-based learning activities and science interest (Gebbels, Evans, & Murphy, 2010; Howitt, Upson, & Lewis, 2011; Messina, 2000; Rursch, Luse, & Jacobson, 2010). Specifically, we sought to determine whether inquiry-based activities result in interest levels that are different relative to non-inquiry-based activities. For our day camp we selected six activities that were inquiry-based and three non-inquiry-based activities that happened to be mathematical. The fact that our non-inquiry-based activities were also mathematical was coincidental. We do not assert that inquiry-based learning is incompatible with the study of mathematics. As Chang (2011) demonstrates, inquiry-based learning is consistent with effective mathematical instruction.

Background

National 4-H leaders recognize the importance of STEM initiatives for our nation's future (4-H National Headquarters, 2008). As a result, preparing young people for the challenges of the 21st century by engagement in science programs has become a national 4-H mission mandate (4-H National Headquarters, 2011). Concern is growing that the United States will be unable to mount a competitive and efficient 21st century workforce given American students' inadequate mastery of science and math (United States Department of Education, 2009). Furthermore, various reports suggest that U.S. K-12 students are performing poorly in science relative to students from other countries (Hanushek, Peterson, & Woessmann, 2012; Program for International Student Assessment, 2009).

Non-formal education programs, such as 4-H, have a vital role to play in helping young people become responsible and productive citizens (Fox, Schroeder, & Lodl, 2003; Knowlton-Ward, 1996). Non-formal education programs can be instrumental in complementing and supplementing learning that has traditionally been provided by formal institutions such as schools (Astroth, 1996). For example, 4-H, with its emphasis on inquiry, application, and action, has potential for developing in youth an increased interest in science (Heck, Carlos, Barnett, & Smith, 2012). For youth learning science, non-formal learning environments such as after-school programs and 4-H camps are ideally suited for experiential activities that are designed to foster scientific inquiry (Bourdeau, 2004).

Methods

A total of 14 students (from 10 families) enrolled and participated in the camp. Students were placed into two groups of 3rd and 4th grade students, and one group of 5th and 6th grade students. In each group, the female to male ratio was approximately equal to one. To foster collaboration, students remained in the same group during the 3-day camp. The groups rotated among eight instructors, each facilitating a different STEM activity associated with a main subject area (Table 1.). Allotted time for each activity (except Egg Drop) was approximately 1 hour. (Egg Drop required on-going participation throughout the 3-day camp.) Camp instructors were 4-H leaders, current teachers, an engineer, and a school psychologist. Instructors were provided activity instructions and purpose, and materials necessary to lead their activity several weeks prior to the camp's start date.

The activities came from lesson plans borrowed from various university and other educational resource center web sites. All activities were modified from their original version.

Table 1.
STEM Activities and Subjects

Activity Name	Subject
Picture This	Math
Construction	Engineering
M&M Probability	Math
Float My Boat	Physics
Ice Cream in a Bag	Physics
Pipe Cleaner Towers	Engineering
Pendulums	Physics
Lowest Score	Math
Egg Drop	Engineering

Data Collection

Before dismissal on the third day, students completed a questionnaire that assessed 1) whether camp activities increased their interest in STEM disciplines, 2) the activities deemed most enjoyable, and 3) their overall impression of the camp. Approximately 2 weeks following the camp's conclusion, parents and guardians were mailed a questionnaire intended to ascertain whether they had observed any difference in their child's (children's) interest regarding STEM disciplines and parents' and guardians' overall impression of the camp. Two weeks after the questionnaires were mailed, parents and guardians were telephoned and gently reminded to return the questionnaire if they had not already done so. Six (out of 10) of the parent/guardian questionnaires were ultimately returned fully completed.

Instrumentation

The instrument completed by students was a 14-item, pencil-and-paper questionnaire that assessed:

1. Which activities encouraged subject matter interest,
2. Which activities were enjoyed most,
3. Student willingness to participate in a similar, future camp, and
4. Student willingness to recommend similar camp to friends.

The instrument completed by parents and guardians was a 10-item, pencil-and-paper questionnaire that assessed:

1. Whether their child (children) talked about the camp, demonstrated any of the camp activities, or displayed an increased interest in STEM areas,

2. Their willingness to recommend and/or support a similar, future camp, and

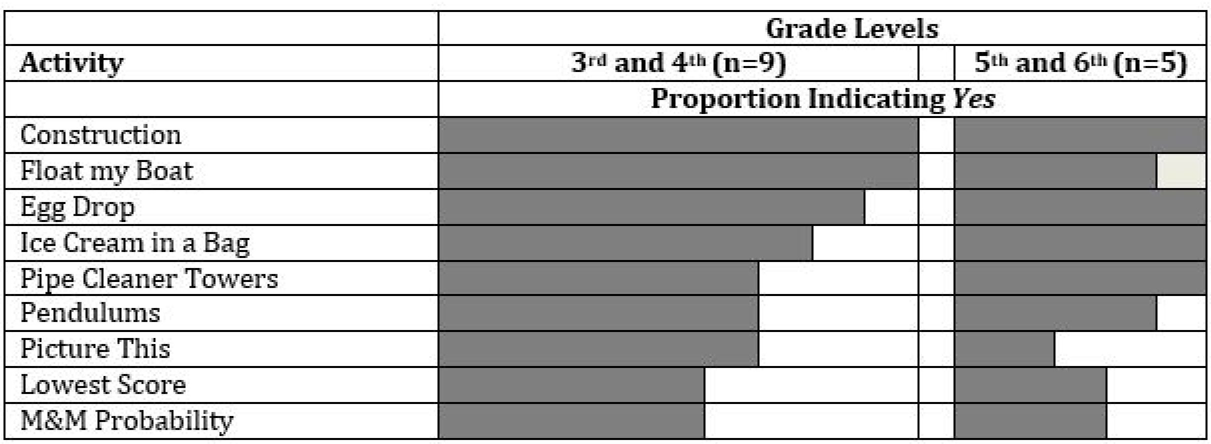
3. Whether they would approve if their child (children) demonstrated interest in pursuing a career in a STEM discipline.

Findings

At the conclusion of the camp, students were instructed to answer a short questionnaire. One section of the questionnaire queried the extent to which each activity promoted interest in STEM subjects. The proportion of the students indicating the activity stimulated their interest is given in Table 2 (by grade level).

Table 2.

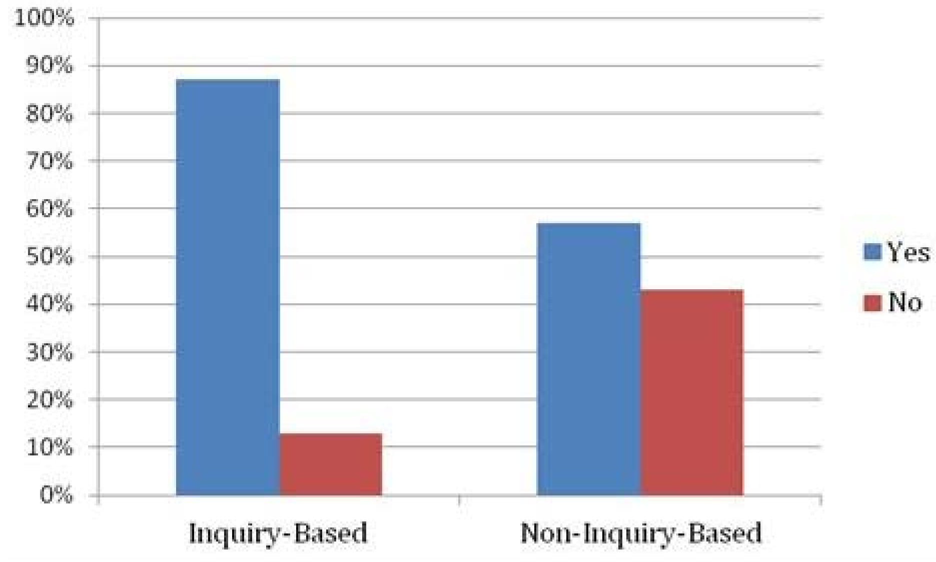
Effect of Activity on STEM Interest



STEM interest data is also displayed in Figure 1. This figure shows the percent of responses indicating whether interest was stimulated. In Figure 1 the responses are grouped by activity category (inquiry-based and non-inquiry-based). In Figure 1, student responses by grade level were combined.

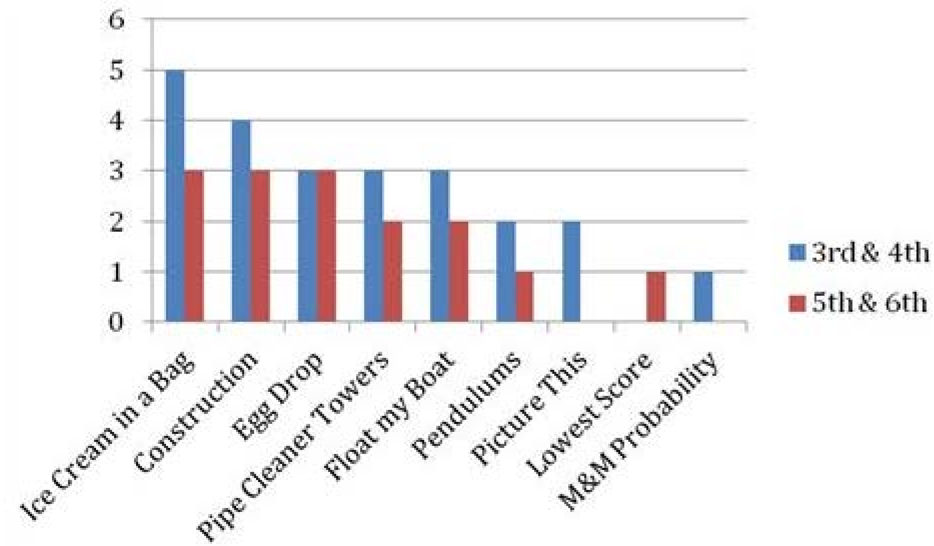
Figure 1.

Effect of Activity Category on STEM Interest



Students were also asked to identify their three favorite activities (ranking not considered). The number of students indicating the activity was one of their top three is given in Figure 2 (by grade level). (Note that not all of the 3rd and 4th grade students completed this question fully, thus their responses do not total 27.)

Figure 2.
Votes for Favorite Activity



Two weeks following the conclusion of the camp, each family was sent a questionnaire by mail. The questionnaire was directed to the parent or guardian in each family responsible for enrolling their child (children) in the camp. A cover letter sent with the questionnaire announced that complete and honest responses would be useful for improving future camps. Parents and guardians were asked to return completed questionnaires using the self-addressed stamped envelope that had accompanied the questionnaire. They were also asked not to identify themselves or their child (children). Their responses are shown in Table 3.

Table 3.

Parent and Guardian Questions and Responses

	Yes	No
Did your child (children) talk positively about the camp?	6	0
Since camp, has your child (children) demonstrated any of the activities from camp?	4	2
Since camp, has your child (children) shown an increased interest in STEM areas?	5	1
Since camp, has your child (children) talked about experiments or the scientific method?	5	1
Would you encourage your child (children) to attend a similar camp in the future?	6	0
Would you recommend a similar camp to your friends' children?	6	0
Would you like your child (children) to pursue a career as a scientist?	6	0

In regard to student responses, threats to validity were addressed by developing questions that were short, concise, and easily understood. For example, for each activity, students were asked to indicate (yes or no) whether the activity made them want to learn more about science and math. Given nine activities, each questionnaire contained nine questions that were identical except for the activity name. Another question asked students to list their three favorite activities (three that were most favored). We have no reason to believe that students failed to understand the questions. As a result, the study appears to have face validity.

In an attempt to address validity and reliability concerns, each student was asked to answer two sets of questions. The first set queried the extent to which each activity increased their interest in science and math. The second set asked them to list the three activities they enjoyed most. It is reasonable to assume that in regard to our STEM camp an activity that increased interest was likely enjoyable, and an enjoyable activity would have stimulated interest. In the study, threats to both validity and reliability are believed to be minimal because the activities that tended to promote interest in science and were also the most favored.

Discussion

As shown in Table 2, a majority of participants indicated each activity positively influenced their interest in STEM subjects. However, not every activity resulted in participants unanimously agreeing that their interest was stimulated. Activities with the largest positive responses were those that were inquiry-based. For example:

- The activity Construction gave students the opportunity to build structures that were either tall or strong. Students were encouraged to anticipate the necessary materials and designs that would be conducive to their goal and then to test their theories. Following the completion of their structures, students collaboratively reflected on the relative success of various designs and useful materials.

- Float My Boat required students to theorize boat size and shape in regard to flotation ability. Students then tested their predictions by building and then loading boats with increasingly heavier weights, and finally recording observations.

- Ice Cream in a Bag provided students the opportunity to experiment with quantities of ice and salt in regard to the formation of ice cream. Several experiments were conducted, each requiring a change in only one variable. Students theorized, experimented, and then recorded results.

- Pipe Cleaner Towers was similar to Construction. Students theorized designs and then experimented with the number of pipe cleaners and configurations while building a freestanding tower.

- For Egg Drop, students worked in teams to complete a structure that would "catch" a raw egg (leaving it intact) when dropped from a height of approximately 6 feet. Students collaborated in anticipating the appropriate materials and structure design that would successfully support a dropped egg. Of all the activities, this required the most teamwork and communication.

According to responses (Table 2), activities less effective at promoting interest were the non-inquiry-based activities (e.g., Picture This, M&M Probability, and Lowest Score). Picture This required students to use simple multiplication and division to reduce and enlarge objects to scale. With M&M Probability students were introduced to the process of determining probabilities. Lowest Score was a board game requiring reasoning and mathematical operations to solve problems involving whole numbers. While these mathematical activities were experiential, they were not inquiry-based.

According to Figure 2, the activities that were inquiry-based were also popular. For example Ice Cream in a Bag, Construction, Egg Drop, Float my Boat, and Pipe Cleaner Towers were rated favorably by camp participants. (Picture This, Lowest Score, and M&M Probability received few favorable ratings.) Finally, all students said they had fun at camp, would recommend the camp to their friends and siblings, and would like to participate in a similar camp in the future.

Among the parents and guardians who reported, there was unanimous agreement that the camp was successful (see Table 3). Five of the six parents and guardians reported an increased interest in STEM subjects by camp participants. Five parents and guardians also reported their child or children mentioning experimentation or the scientific method in conversations following the camp's conclusion. Additionally, four parents and guardians witnessed their students demonstrating STEM activities at home. All of the parents and guardians said they would encourage their child or children to attend a similar camp in the future, and would recommend a similar camp to others.

Limitations

The study reported here was limited by the small sample of student participants. Obviously, a small sample weakens the ability to generalize these results to populations of elementary and middle school students. While this sample size limits the study's generalization capacity, it does not necessarily result in findings that are invalid or prevent the development of useful conclusions. Other researchers using similar procedures for researching inquiry-based learning have successfully generated results from small samples. For example, Smith and Enfield (2002), in their research that evaluated teens as facilitators of inquiry-based science, developed multiple conclusions from results that used a sample size of 15. Also, Nuangchalerm and Thammasena (2009), researching inquiry-based learning in early childhood education employed a sample size of 10. However, to address the study's limited sample size other research is warranted that employs larger samples.

Additional studies should further investigate whether inquiry-based learning activities affect scientific interest for students relative to non-inquiry-based activities. In these studies it will be important to accurately describe inquiry-based learning as one subset of experiential learning. Also, an added layer of investigation should focus on the affect that mathematical activities have on scientific interest. For example, do mathematical activities result in a vacuity of student interest, or are students simply put-off by non-inquiry-based learning? As the study reported here suggests, one or both of these activity categories fall short in stimulating scientific interest and enjoyment for young students.

Summary

A summer day camp for elementary and middle school students provided STEM activities that were either experiential and inquiry-based, or experiential and non-inquiry-based. Results indicated that inquiry-based STEM activities were most successful at stimulating interest. This finding is significant because students who show an interest in science are more likely to study science and choose a scientific career. Inquiry-based learning also exposes students to the processes and procedures important for scientific work (Clarke, 2010; Skelton et al., 2012). However, the development of process skills inherent in inquiry-based learning—reasoning, problem-solving, and creativity—help facilitate the completion of projects and tasks that individuals will confront throughout their lives. This type of learning therefore has value for all students.

References

Albright, K., Petrulis, R., Vasconcelos, A., & Wood, J. (2012). An inquiry-based approach to teaching research methods in information studies. *Education for Information*, 29(1), 19-38.

Astroth, K. (1996). Leadership in non-formal youth groups: Does style affect youth outcomes? *Journal of Extension* [On-line], 34(6). Available at: http://www.joe.org/joe/1996december/rb2.html

Blair, R. B., Meyer, N., Rager, A. B., Ostlie, K., Montgomery, K. L., & Carlson, S. (2004). Best practices for environmental field days: Structuring your event for fun and learning. *Journal of Extension* [On-line], 42(5) Article 5TOT4. Available at: http://www.joe.org/joe/2004october/tt4.php

Bourdeau, V. D. (2004). 4-H experiential education: A model for 4-H science as inquiry. *Journal of Extension* [On-line], 42(5) Article 5TOT3. Available at: http://www.joe.org/joe/2004october/tt3.php

Chang, J. M. (2011). A practical approach to inquiry-based learning in linear algebra. *International*

Journal of Mathematical Education in Science and Technology, 42(2), 245-259.

Clarke, K. C. (2010). A science, engineering and technology (SET) approach improves science process skills in 4-H animal science participants. *Journal of Extension* [On-line], 48(1) Article 1IAW3. Available at: http://www.joe.org/joe/2010february/iw3.php

Education Development Center, Inc. (2012). Intro to inquiry learning. Retrieved from: http://www.youthlearn.org/learning/general-info/our-approach/intro-inquiry-learning/intro-inquiry-learning

Fox, J., Schroeder, D., & Lodl, K. (2003). Life skill development through 4-H clubs: The perspective of 4-H alumni. *Journal of Extension* [On-line], 41(6) Article 6RIB2. Available at: http://www.joe.org/joe/2003december/rb2.php

Gebbels, S., Evans, S. M., & Murphy, L. A. (2010). Making science special for pupils with learning difficulties. *British Journal of Special Education*, 37(3), 139-147.

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. Science Education, 86(5), 693-705.

Hanushek, E. A., Peterson, P. E., & Woessmann, L. (2012). Achievement growth: International and U.S. state trends in student performance. Harvard Kennedy School. Retrieved from: http://www.hks.harvard.edu/pepg/PDF/Papers/PEPG12-03_CatchingUp.pdf

Heck, K. E., Carlos, R. M., Barnett, C., & Smith, M. H. (2012). 4-H participation and science interest in youth. *Journal of Extension* [On-line], 50(2) Article 2FEA5. Available at: http://www.joe.org/joe/2012april/a5.php

Howitt, C., Upson, E., & Lewis, S. (2011). "It's a mystery!": A case study of implementing forensic science in preschool as scientific inquiry. *Australasian Journal of Early Childhood*, 36(3), 45-55.

Ireland, J. E., Watters, J. J., Brownlee, J., & Lupton, M. (2012). Elementary teacher's conceptions of inquiry teaching: Messages for teacher development. *Journal of Science Teacher Education*, 23(2), 159-175.

Jansen, B. A. (2011). Inquiry unpacked: An introduction to inquiry-based learning. *Library Media Connection*, 29(5), 10-12.

Knowlton-Ward, C. (1996). Life skill development related to participation in 4-H animal science projects. *Journal of Extension* [On-line], 34(2) Article 2RIB2. Available at: http://www.joe.org/joe/1996april/rb2.php

Markowitz, D. G. (2004). Evaluation of the long-term impact of a university high school summer science program on students' interest and perceived abilities in science. Journal of Science Education and Technology, 13(3), 395-407.

Messina, P. (2000). Footprints as inquiry-based learning tools. *Journal of Geoscience Education*, 48(5), 667-72.

Nuangchalerm, P., & Thammasena, B. (2009). Cognitive development, analytical thinking and learning satisfaction of second grade students learned through inquiry-based learning. *Asian Social Science*, 5(10), 82-87.

Program for International Student Success. (2009). *PISA 2009 results: What students know and can do.* Retrieved from: http://www.oecd.org/pisa/pisaproducts/48852548.pdf

Rursch, J. A., Luse, A., & Jacobson, D. (2010). IT-Adventures: A program to spark IT interest in high school students using inquiry-based learning with cyber defense, game design, and robotics. *IEEE Transactions on Education*, 53(1), 71-79.

Skelton, P., Seevers, B., Dormody, T., & Hodnett, F. (2012). A conceptual process model for improving youth science comprehension. *Journal of Extension* [On-line], 50(3) Article 3IAW1. Available at: http://www.joe.org/joe/2012june/iw1.php

Smith, M. H., & Enfield, R. P. (2002). Training 4-H teen facilitators in inquiry-based science methods: The evaluation of a "step-up" incremental training model. *Journal of Extension* [On-line], 40(6) Article 6FEA3. Available at: http://www.joe.org/joe/2002december/a3.php

Smith, M. H., Meehan, C. L., Enfield, R. P., George, J. L., & Young, J. C. (2004). Improving county-based science programs: Bringing out the science teacher in your volunteer leaders. *Journal of Extension* [On-line], 42(6) Article 6FEA5. Available at: http://www.joe.org/joe/2004december/a5.php

4-H National Headquarters. (2011). *Mission mandates*. 4-H National Headquarters Fact Sheet. Retrieved from: http://www.csrees.usda.gov/nea/family/res/pdfs/Mission_Mandates.pdf

4-H National Headquarters. (2008). Evaluating the 4-H science initiative: Early findings and recommendations. Retrieved from: http://www.4-h.org/uploadedFiles/About_Folder/Research/Science/Implementation%20Report_FINAL.pdf

United States Department of Education. (2009). *The facts about science achievement*. Retrieved from: http://www2.ed.gov/nclb/methods/science/science.pdf

Wu, H., & Wu, C. (2011). Exploring the development of fifth graders' practical epistemologies and explanation skills in inquiry-based learning classrooms. *Research in Science Education*, 41(3), 319-340.

Zeek, S. (2011). Teaching the research paper through inquiry-based instruction. *Inquiry*, 16(1), 75-85.
