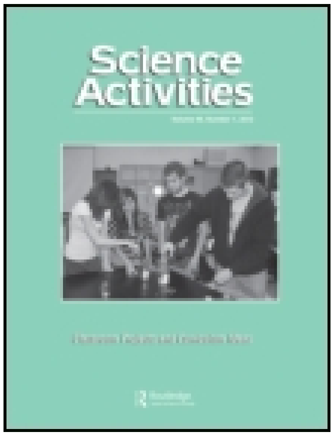


Science Activities: Classroom Projects and Curriculum Ideas
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/vsca20

# Investigating Human Impact in the Environment with Faded Scaffolded Inquiry Supported by Technologies

Todd Campbell [a] , Max Longhurst [b] , Aaron M. Duffy [b] , Paul G. Wolf [b] & Robin Nagy [b]
[a] University of Massachusetts Dartmouth , Fairhaven , MA
[b] Utah State University , Logan , UT
Published online: 06 Dec 2012.

*Science Activities*, 49:99–107, 2012

ISSN: 0036-8121 print / 1940-1302 online
DOI: 10.1080/00368121.2012.685112

Routledge
Taylor & Francis Group

# Investigating Human Impact in the Environment with Faded Scaffolded Inquiry Supported by Technologies



**Todd Campbell**
University of Massachusetts Dartmouth, Fairhaven, MA

**Max Longhurst, Aaron M. Duffy, Paul G. Wolf, and Robin Nagy**
Utah State University, Logan, UT

**ABSTRACT** Teaching science as inquiry is advocated in all national science education documents and by leading science and science teaching organizations. In addition to teaching science as inquiry, we recognize that learning experiences need to connect to students' lives. This article details how we use a sequence of faded scaffolded inquiry supported by technologies to engage students meaningfully in science connected to their lives and schoolyards. In this approach, more teacher guidance is provided earlier in the inquiry experiences before this is faded later in the sequence, as students are better prepared to complete successful inquiries. The sequence of inquiry experiences shared in this article offers one possible mechanism for science teaching supported by technologies as an exemplar for translating teaching "science as inquiry" into practice.

**KEYWORDS** environment, inquiry, technology

## INTRODUCTION

Getting secondary students outside the classroom and into the schoolyard can be invigorating and an excellent space for learning about the environment through science as inquiry. This article reveals how university faculty leading a National Science Foundation (NSF) funded project have collaborated with eighth-grade science teachers using a sequence of faded scaffolded inquiry experiences (Slater, Slater, and Shaner 2008) supported with technologies to teach about human impact in the environment. The sequence of faded scaffolded inquiry experiences is designed so that the teacher models the development of a researchable question aligned to valid procedures and the use of technologies early on in the inquiry sequence. This scaffolding early on is followed by subsequent inquiries later in the sequence where students continue to investigate human impact in the environment through "class-designed" and finally "student group–designed" researchable questions and procedures connected to technologies for communicating the methods and results of their inquiries. Table 1 identifies example eighth-grade state (e.g., Utah) and national targeted human impact in the environment and inquiry standards. The details of the sequence

Address correspondence to Todd Campbell, University of Massachusetts Dartmouth, Department of STEM Education, 200 Mill Rd. Suite 30, Fairhaven, MA 02719, USA. E-mail: todd.campbell@umassd.edu

**TABLE 1** Targeted State and National Standards

| Standards |
|---|
| • Analyze human influence on the capacity of an environment to sustain living things (Utah State Office of Education 2003). |
| • Changes in environmental conditions can affect the survival of individual organisms and entire species (American Association for the Advancement of Science 1993). |
| • In all environments, organisms with similar needs may compete with one another for limited resources, including food, space, water, air, and shelter (American Association for the Advancement of Science 1993). |
| • Students experience and begin to understand the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work (National Research Council 2000, 23). |



of scaffolded inquiries supported by technologies are shared next as one exemplar of teaching "science as inquiry."

## MATERIALS

- Student Tutorials for Creating Picasa Web Album, Google Doc spreadsheet, and Google Web site from template (see Figure 1): http://tinyurl.com/7w7cfkf
- Digital camera
- Hula hoops
- Field-recording sheets
- Photo log: http://tinyurl.com/7eeyu7j
- Plant data sheet: http://tinyurl.com/7nv79ey
- Area description sheet: http://ttinyurl.com/6skdls8
- Pit traps (i.e., plastic cup, water/soap, small garden spade)

[Teacher resource for learning more about Google Sites and Google Resources: http://www.google.com/sites/help/intl/en/overview.html]

## PROCEDURES

## Day 1

### *First Inquiry Experience in Sequence*

The first day (45-min class period) of our module begins by building an environment with the teacher, as researcher, searching to identify ways that humans impact the local environment with the students helping as research assistants. The teacher shares the following research question and procedures he or she has designed and lets the class know that they will be working with him or her to collect data and make conclusions based on the collected data. The research question posed is "Do areas that have been more impacted by human activities have lower plant and animal diversity?" To answer this question, the teacher leads the students into the schoolyard where the teacher previously identified two to three areas with differing levels of human impact (e.g., football field vs. area of school grounds that is not regularly maintained). Using hula hoops, the teacher demonstrates how students will collect data by dropping the hula hoop at regular intervals along a transect line the teacher has previously laid out (e.g., every 10 m) and counting the number of different types of plants within the interior space of the hula hoop (see Figure 2). Equal numbers of hula hoop samples are taken at each area for a fair comparison. (*Teacher Note*: To provide more reliable data for contrasting different areas of investigation, at least three hula hoop samples should be laid out in each area. Additionally, it would be best for each hula hoop team to collect at least one data-gathering site at each of the different areas. *Reminder*: Day 1 is planned for a 45-min class period, so some advance planning and attention to all that is required during this initial day is needed for completion during this allotted amount of time.) Additionally, students take a picture of each different kind of plant identified with the digital camera and, using the field-recording sheets, document the number of different types of plants in each hula hoop sample. Students are also asked to record additional questions they think might be important to answer about human impact in the environment based on observations they are making in the field during this initial data collection time (e.g., Does the amount of human impact in an area impact the number of different kinds of insects that can be found in that area?). Finally, before the end of the first day, students set pit traps in each of the two to three areas with differing levels of human impact. These are set by digging a hole the size of the plastic cup, placing

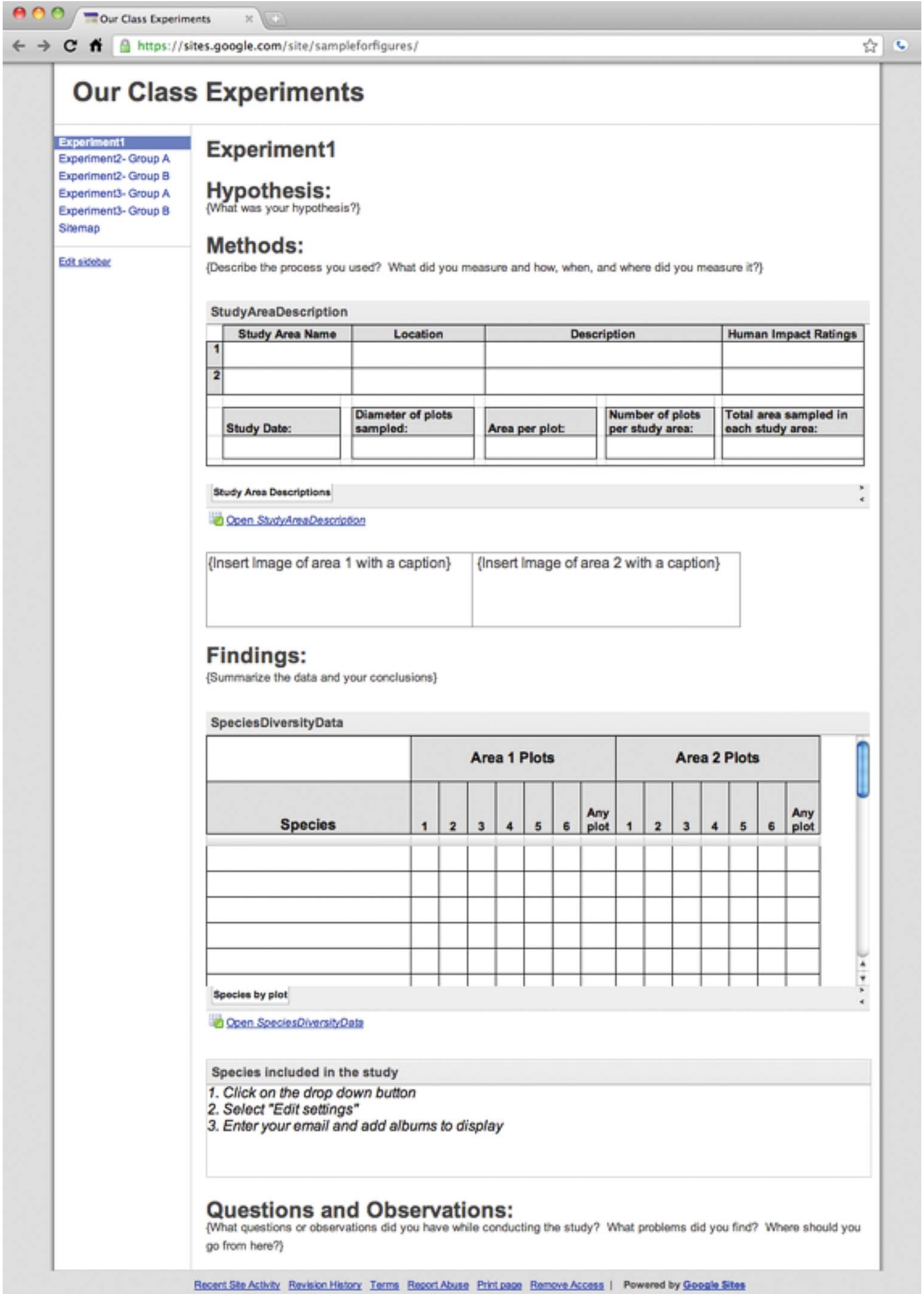


**FIGURE 1** Example of Google site (color figure available online).

**FIGURE 2** Hoop used for sampling (color figure available online).



the cup inside the hole, and pouring soapy water inside the cup. The pit traps are left as an optional focus for later inquiries in Days 3 to 10. (*Safety Precautions*: The teacher should examine the potential areas that will be visited beforehand to identify any poisonous plants and insects that may be problematic and either avoid areas with such concerns or share these concerns and strategies for avoiding them with students.)

## Day 2

The teacher introduces students to the Google site Web template, Picasa, and the Google Docs spreadsheet template (see Student Tutorials for Creating Picasa Web Album, Google Doc spreadsheet, and Google Web site from template: http://tinyurl.com/7w7cfkf). This is organized so that three to four student groups are working to develop three to four parallel Web sites (i.e., Web sites that will contain the same question, data, and pictures, but each individual group will determine their own conclusions and identify ideas for future research questions). (*Teacher Note*: While we believe these tutorials are sufficient for providing help in preparing for instruction, partnering with a school or district instructional technologist as needed can provide another layer of support.)

## Day 3

After creating Web sites on Day 2, the beginning of Day 3 is spent having groups share their Web sites, the conclusions, and additional questions they have identified. In our implementation of this module, when we compared an area like a football field to a part of the school ground that was not maintained as an example, students were able to conclude that more kinds of plants were found in the areas that were not maintained. Whether the data collected at the school are or are not supportive of this claim, we see either outcome as still tremendously valuable in that it allows students to engage in the process of science that is extracting explanation from evidence (Johnston 2008) in the complexity of what is the natural world.

### *Second Inquiry Experience in Sequence*

The latter part of Day 3 is devoted to starting the second inquiry experience in the sequence. In this second opportunity, the students are brought in as co-researchers to work with the teacher/researcher to develop a researchable question and procedures. Initially, students are placed into three to four student groups where, as a group, they developed one researchable question in consultation with the teacher. These groups also design a process of data collection and determine how they will share their information modeled after the first inquiry experience through using Google Sites, Google Docs, and Picasa.

## Day 4

Student groups begin this day by sharing their researchable question and procedures with the class for feedback and final revisions before beginning data collection. After students share, the remainder of this day is used as a data collection day. A few examples of research questions we have seen identified in the second sequence include "Is the amount of human impact in an area related to insect diversity in the areas?" and "Is there any difference in the amount of soil runoff when comparing an area more impacted by humans compared to an area less impacted?" (*Teacher Note*: The findings emerging from these questions are not cause and effect, and caution needs to be used in interpretation of the data.) To answer the first question, students compared the number of different kinds of insects collected from the pit traps across the areas with different human impact. To answer the second question, students poured water over plots in the two different areas (i.e., more and less human impacted areas) and compared the amount of soil runoff between the two areas. (*Note*: In order to measure "soil runoff" in a more quantitative fashion, teachers might consider using a soil infiltrometer. An inexpensive inflitrometer can be constructed using the following instructions: http://www.cns-eoc.colostate.edu/docs/Infiltrometer_Instructions.pdf.) These are shared as just a few examples of additional research questions students might work to answer. During data collection on Day 4 students are reminded to use a revised field-recording sheet based on specific revisions needed for their investigation and to collect photo documentation that can be used as supplemental resources for communicating their investigation procedures and results.

## Day 5

Student groups work together to use data collected in the second inquiry experience to transfer data from their field-recording sheets to a Google Doc spreadsheet, upload photos into Picasa, and use the Google site template to make their group Web sites. Student groups also used this day to prepare for group presentations for the following day (see Figure 3 as an example of a Web site created with the Google site template).

## Day 6

Like Day 3, this day is spent having groups share their Web sites (i.e., their research questions, procedures, data, conclusions, and additional questions that need to be investigated). After the three to four student groups present, the day concludes with students working in small groups of two to three students considering one additional question they think will be important to answer through inquiry to continue to build a more and more sophisticated understanding of humans' impact in the environment. During this final part of the lesson, students are reminded to reflect on what they learned in the first and second inquiry in the sequence and to revisit the questions identified most recently in the second inquiry experience.

## Days 7–10

### *Third Inquiry Experience in Sequence*

The final three class periods are set up to facilitate student investigation demonstrating both their ability to engage in scientific inquiry to develop a deeper understanding of the impacts of humans in the environment. During the third inquiry in the sequence, students who worked in groups of two to three at the end of Day 6, are expected to now identify a researchable question, design a procedure, revise Web page templates to match their design, collect data, make conclusions, and finalize a Web page for communicating their investigations and results. As with any science lesson, the teacher's role is to ensure that students progress toward successful achievement of the targeted outcomes, but in this particular inquiry, the students are expected to take on a more central role in shaping the direction and process of this inquiry by reflecting back on past inquiries completed in the sequence and by engaging with peers and the teacher. To ensure that both the needs of individual teacher's (e.g., flexibility to include in their curriculum sequence as needed) and the needs of their students are met, three options for teacher delivery of the third iteration are offered for completion of the third inquiry: (a) in-class completion, (b) combination of in-class and out-of-class time, or (c) out-of-class time.

## ASSESSMENT

A rubric for assessing students' capacity to complete scientific inquires is provided in Table 2. This rubric can be used as a formative assessment early on at the conclusion the first and second inquiry in the sequence and as a summative assessment after the third inquiry experience. Additionally, pre and post multiple-choice items can be used to assess students' understanding of human impact in the environment. The following are examples of four assessment items aligned to the Utah State Office of Education (2003) state standard referenced earlier (i.e., Analyze human influence on the capacity of an environment to sustain living things):

1. How is an "old growth" forest (one that has never been logged) different from a replacement forest planted by humans?
   A. **Old growth forests have more biodiversity.**
   B. Old growth forests have less biodiversity.
   C. Replacement trees will become larger.
   D. Replacement trees will grow slower.
2. Why are scientists concerned about the destruction of rain forests?
   A. Much of the wood harvested is going to waste.
   B. **Many species of plants and animals are lost.**
   C. People living nearby will not stay in these areas.
   D. Animals must change their diets to eat the new foods.
3. A newspaper reporter notices that a pair of peregrine falcons have built a nest on her building. Over the next 2 months, she watches them hatch their eggs, feed the chicks and teach them to fly. She writes a weekly report for the newspaper and documents their growth and behavior. How has the reporter used scientific methods?

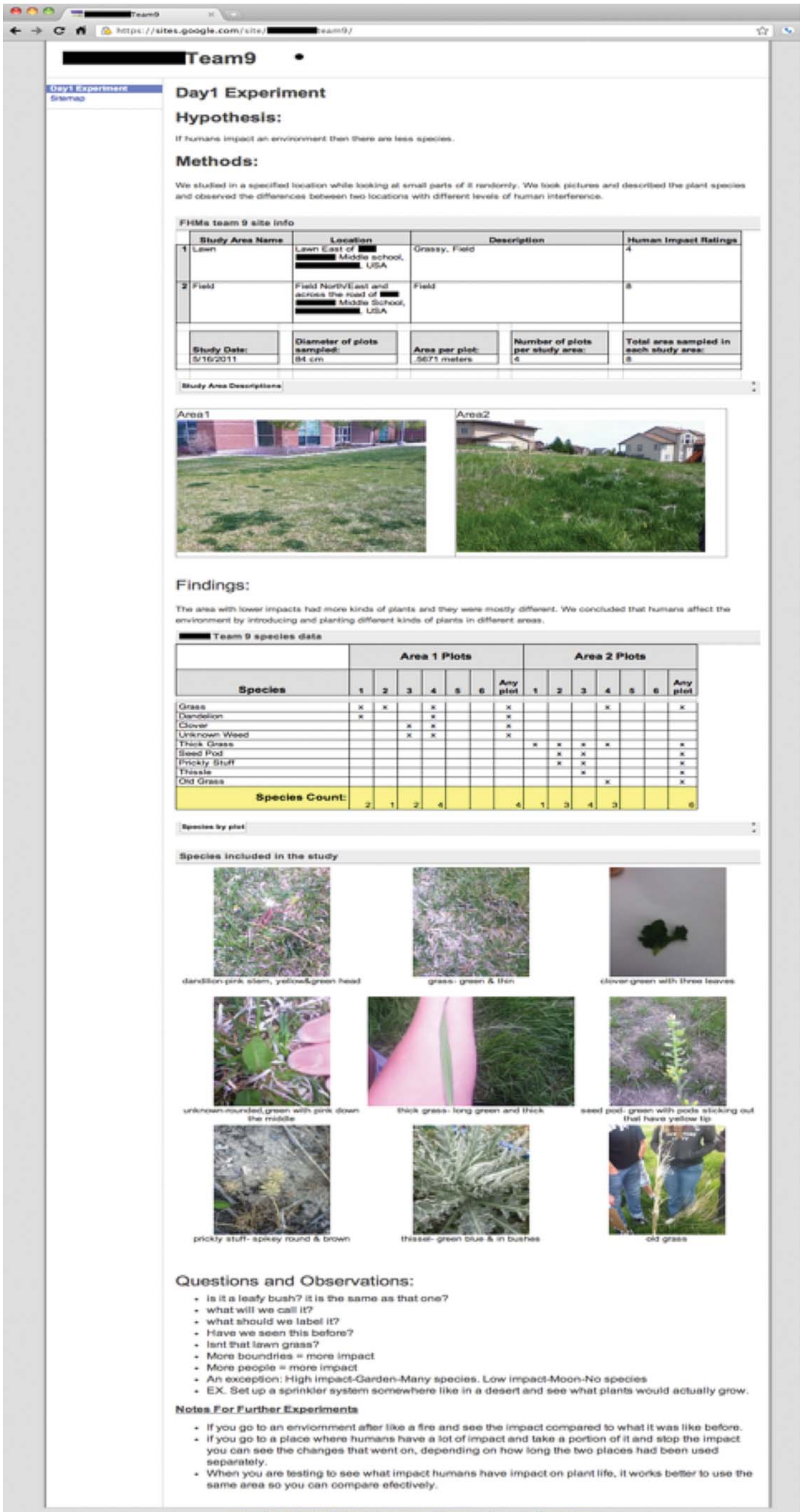


**FIGURE 3** Example Web page screen (color figure available online).

**TABLE 2** **Scientific Inquiry Rubric**

| Indicator | Low 1 | Average 2 | High 3 |
|---|---|---|---|
| Learner engages in scientifically oriented questions. | • Questions do not address the natural world, and/or generate a hypothesis that is not testable.<br>• Variables are not clearly defined. | • Although questions are simple, they generate a testable hypothesis. | • Questions are compound, and generate a testable hypothesis. |
| Learner gives priority to evidence in responding to questions. | • Evidence is inaccurate or affective.<br>• Explanation is inaccurate, overly simplified, or factual. | • Evidence is common knowledge.<br>• Explanation is accurate and descriptive, but not higher order. | • Evidence is scientifically accurate.<br>• Explanation is compound and higher order. |
| Learner formulates explanations from evidence. | • Explanation expresses an opinion.<br>• Explanation is simply a summary of methods and results. | | |
| Learner connects explanations to scientific knowledge. | • Learner is unable to connect observations to background knowledge. | • Background knowledge is used to formulate a simple explanation about the natural world. | • Evidence combined with background knowledge is used to formulate a compound explanation about the natural world. |
| Learner communicates and justifies explanations. | • Learner does not communicate clearly. | • Learner communicates clearly. | • Learner communicates clearly and uses evidence to justify explanations. |

*Note*: Indicators taken from National Research Council (2000).

A. she has written about the things that are important to her.
B. she has asked other people in her office to help watch the falcons.
C. she has appreciated the beauty and wonder of nature.
D. **she has made observations, recorded and reported them.**

4. When land is cleared for paving a parking lot, what happens to the ability of that land to support living things?
A. **the number and kind of living things will be greatly reduced.**
B. the number and kind of living things will be greatly increased.
C. the organisms that once lived there will go to another place.
D. the organisms that once lived there will become extinct.

*Note*: All questions were taken from Jordan School District (2012) and all correct responses are bolded.

We believe these assessments, and others, can serve as beginning measures to both guide instruction (i.e., formative use of rubric and preassessment items) and better understand the extent to which targeted outcomes have been met at the conclusion of the inquiry sequences (i.e., summative use of the rubric and postassessment items).



## DISCUSSION

Leading students from the development of a researchable question to planning the process of data collection, culminating with understandings and findings that lead to deeper investigation is the essence of the sequence of scaffolded inquiry experiences (Slater, Slater, and Shaner 2008). During the three inquiries in the sequence, students become increasingly more capable and invested in the question and process of investigation. The first inquiry establishes the instructor as a researcher who guides the students to look at a defined research question through specific tasks developed by the teacher. During the second inquiry, students take on more ownership as small groups within the class to codevelop, with the instructor, additional research questions that extend the original investigation. Not only are the questions negotiated between the teacher and students, the process of data collection and dissemination of findings are molded with both teacher and student input. The third inquiry in the sequence extends student thinking, investigation, and learning as groups of two to three students identify researchable questions, develop data collection strategies, and establish methods to share understandings and findings. We found this style of instruction to be highly engaging as teachers in our funded NSF project enacted this sequence in local middle schools.

## CONCLUSION

Through this article, we have focused on teaching targeted foundational concepts (i.e., human impact on the environment) in the context of authentic inquiries in a manner consistent with the work of scientists. And we leveraged technologies that permeate students' lives. Our work emerged as science teachers, university science educators, and scientists collaborated to design instruction better aligned with the work of scientists. Our hope is that others can benefit from how we have approached these instructional objectives as we also seek to ever-improve our approaches into the future by reading similar articles shared by others.

(*Teacher Note*: While we see great value in using technologies to support science inquiries in ways aligned with reformed instructional practices [i.e., teaching science as inquiry], we believe other technologies that teachers are more familiar with can also serve this purpose [e.g., inserting a table into a Google Web site instead of inserting a Google Docs spreadsheet]. And just as we suggested that school and district instructional technologist can provide an additional layer of support for using technologies in the inquiry sequences, Mathematics and Science Partnership [MSP] funded state-level grants as well as other professional development opportunities for teachers can provide another layer of support for teachers to enhance their ability in teaching "science as inquiry." One Web resource for learning more about MSP projects is http://www2.ed.gov/programs/mathsci/resources.html.)

## ACKNOWLEDGMENTS

The authors would like to thank Gayle Dowldle, Harrison Beckett, Angela Stewart, Jana Barrow, and Jodi Lunt for collaborating on this module. Funding for this research was provided by the National Science Foundation through a Discovery Research K–12 Project (Award Number: 1020086).

## REFERENCES

American Association for the Advancement of Science. 1993. *Benchmarks for science literacy: A Project 2061 report*. New York: Oxford University Press.

Johnston, A. 2008. Demythologizing or dehumanizing? A response to Settlage and the ideals of open inquiry. *Journal of Science Teacher Education* 19: 11–13.

Jordan School District. 2012. Secondary science, 2012. http://departments.jordandistrict.org/curriculum/science/secondary/archive/grade8/80203.html (accessed February 10, 2012).

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

National Research Council (NRC). 2000. *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

Slater, S. J., T. F. Slater, and A. Shaner, A. 2008. Impact of backwards faded scaffolding in an astronomy course for pre-service elementary teachers based on inquiry. *Journal of Geoscience Education* 56: 408–416.

Utah State Office of Education (USOE). 2003. Secondary core curriculum. http://www.schools.utah.gov/curr/core/corepdf/Scie9-12.pdf (accessed October, 31, 2011).