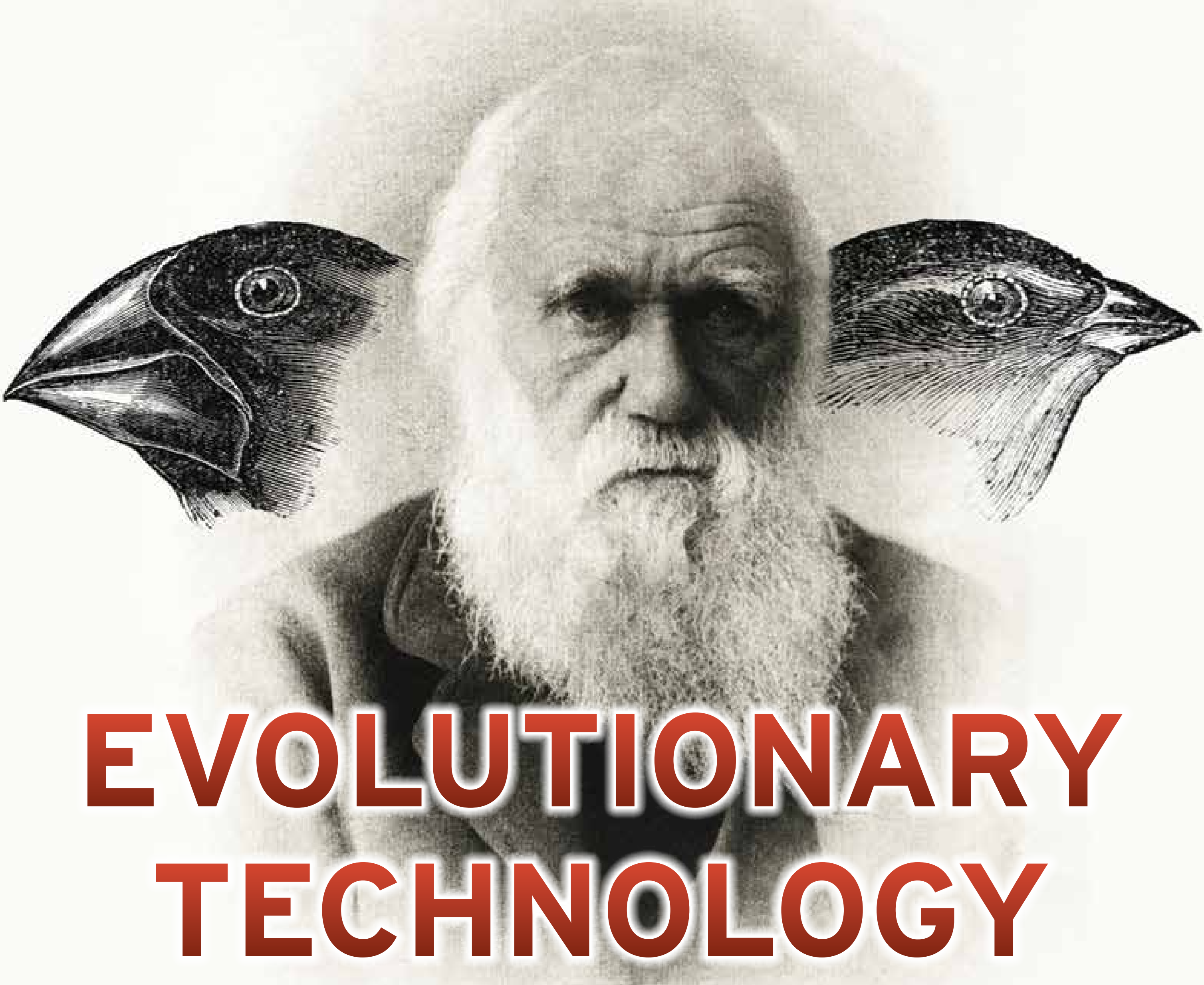


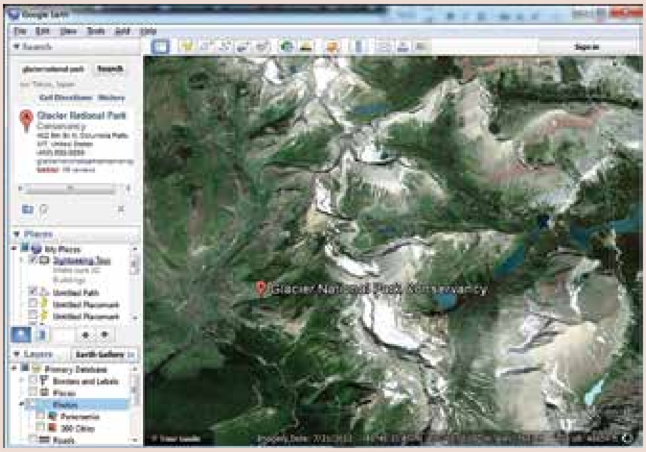
EVOLUTIONARY TECHNOLOGY

Using Google Earth, Cyber Databases, and Geotagged Photos to Enhance Students' Scientific Practices and Understanding of Darwin's Theory of Evolution

by Shiang-Kwei Wang, Hui-Yin Hsu, and Jean Posada

To effectively communicate their research procedures, lab reports, and findings, scientists use technology to produce visual representations of information. Likewise, to prepare students to understand and do science in the digital era, the *Next Generation Science Standards* (NGSS Lead States 2013) foster students' ability to read, interpret, and produce multimodal information to communicate. This set of skills is equivalent to the 21st-century new literacy skills. *New literacy* refers to new forms of literacy made possible by the use of technology. It is the ability to use information and communication technologies (ICTs) to "identify questions, locate information, evaluate the information, synthesize information to answer questions, and communicate the answers to others" (Leu et al. 2004, p. 1572; Hsu, Wang, and Runco 2012). To be fluent in new literacy, students need to be proficient in three important areas (Hsu and Wang 2010): technology skills (the ability to operate computer and network technologies), literacy skills (the ability to read, write, comprehend, and communicate), and cognitive skills (critical-thinking, problem-solving, and research and evaluation skills). This important set of skills parallels the scientific inquiry process and is considered essen-

FIGURE 1 Overview of a map in Google Earth



tial for college and workplace readiness in 21st-century global society.

Our students are digital natives. They use technology to consume, produce, and share information in their daily lives and are accustomed to acquiring and producing knowledge through multimodal formats (Prensky 2001). Students can apply these critical skill sets to schoolwork to solve cognitive problems, specifically in science education, which values hands-on, constructivist, and student-centered approaches. Educators have avidly advocated the idea of helping students practice new-literacy skills across disciplines. In addition, the *Next Generation Science Standards* (NGSS) support the notion that "being literate in science and engineering requires the ability to read and understand their literatures. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics. Reading, interpreting, and producing text are fundamental practices of science in particular, and they constitute at least half of engineers' and scientists' total working time" (NGSS Lead States 2013).

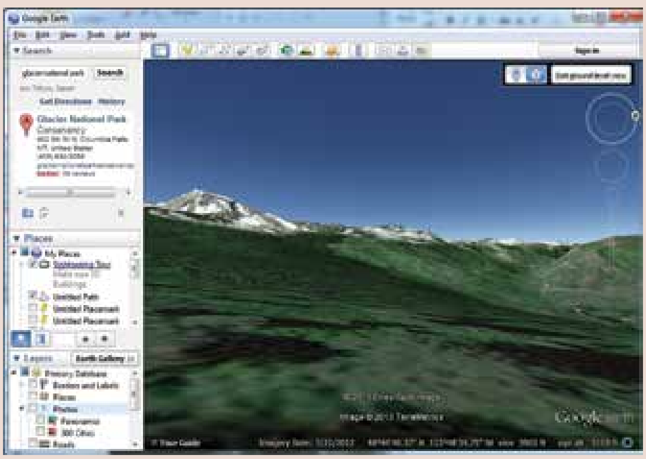
The learning activity described here uses a variety of ICTs and other resources to facilitate students' scientific inquiry and new-literacy practices and allows them to express their understanding of discipline-specific knowledge through multimodal formats (e.g. texts, charts, images, or maps).

Google Earth, cyber databases, and geotagged photos

Google Earth is a 3-D image-mapping database that is widely used in environmental and geographic education and has been adopted by educators as a popular information-consumption tool. It provides students with rich multimedia information and real-time scientific data through the connection with public cyber databases. It can also be used as an information productivity tool to support students in developing and using models to explain, explore, predict, and collect data to test ideas about the phenomena in natural or designed systems. There are a vast number of databases connected with Google Earth; here we specifically focus our discussion on the photo database Panoramio.

Panoramio is a geolocation-oriented photo-sharing website that provides geotagged photos: images that carry geographical location data and are displayed in specific locations in Google Earth. This means that in addition to the 3-D virtual environment, teachers can show students one more layer of information regarding a geographic location. For example, students can visit Glacier National Park on Google Earth to skim the outlook of this area (Figure 1), enter street view (Figure 2), or click on the geotagged photo to see what it would look like if they were standing in front of the exact location (Figure 3). The overview map in Google Earth helps students learn the terrain; the street view provides additional perspective that lets students explore

FIGURE 2 Street-view mode in Google Earth



places around the location through a 360° viewpoint; and the geotagged photos include detailed information and the nuances of locations to allow for close observation or making comparisons. Google Earth's productivity features and its rich data provided by cyber databases enable teachers to engage students in scientific practices while learning about disciplinary core ideas and making connections to the crosscutting concepts.

For this activity, we chose the topic evolution because it is a core idea in *A Framework for K–12 Science Education* (Biological Evolution: Unity and Diversity) in the life-sciences discipline (NRC 2012, p. 139). Prior to the investigation, teachers should discuss the following concepts with the class: Natural selection leads to the predominance of certain traits in a population, and the suppression of others (MS-LS4-4), and adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes (MS-LS4-6) (NGSS Lead States 2013).

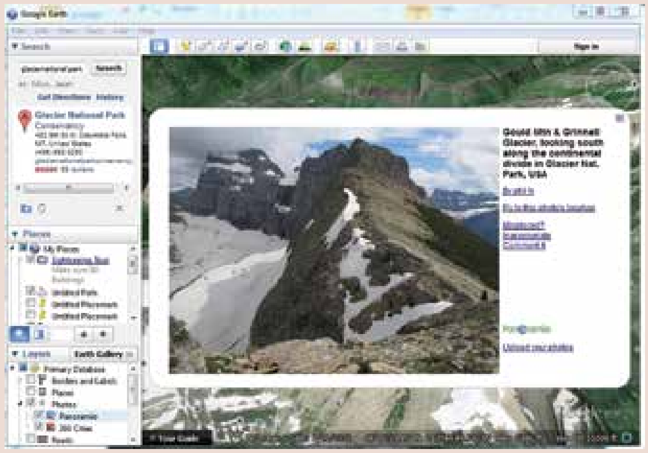
Most curricula use Darwin's Galapagos finches to explore his theory of evolution by natural selection. Teachers can start this activity after students are familiar with the historical background information about the development of Darwin's evolution theory. When activating students' prior knowledge with the theory of evolution, they are usually guided to read Darwin's *The Voyage of the Beagle*, through which they learn to draw connections from the past to predict the future of life on Earth.

Through this activity, students will enact the following scientific practices: Asking Questions and Defining Problems; Developing and Using Models; Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Constructing Explanations; Engaging in Argument From Evidence; and Obtaining, Evaluating, and Communicating Information (NRC 2012). In addition, they will engage with the following crosscutting concepts: Patterns and Cause and Effect (NRC 2012). The map and image information students create can help them identify patterns and cause-and-effect relationships in finches' environmental niche, habitats, food sources, and morphological differences (see Figures 4 and 5).

During one weeklong investigation, middle-grade students develop their skills in forming research questions and hypotheses as well as implementing their research plans.

FIGURE 3 Geotagged-photo mode in Google Earth

You can use the Layers Panel in Google Earth to activate the geotagged-photo viewing mode.



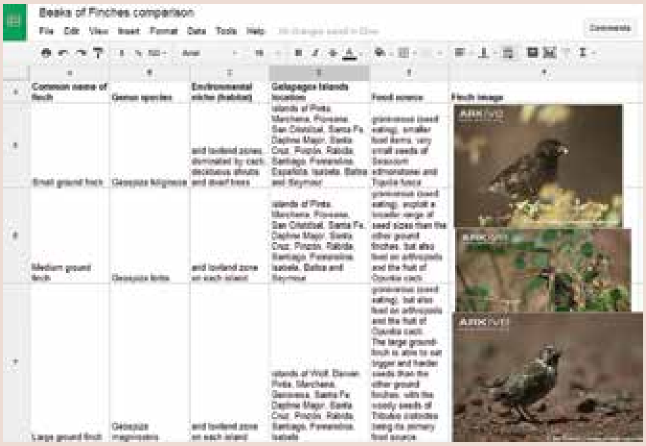
Step 1: Define problems

After teachers activate students' prior knowledge of the theory of evolution, students are given a mission:

> *It is 1835 and you are Darwin's assistant. You have just completed your travels on the famous* Beagle *journey throughout the Galapagos Islands. You helped Darwin take photographs, and imagine you also have access to satellite images. Darwin gave you a list of locations in which various finches were observed. You need to help him figure out if there are morphological differences in the finches located on the various islands. You will use Google Earth (or Google Maps) to create a map reporting the locations in which finches were observed and figure out if there are morphological differences in the finches and why.*

Teachers then start modeling the investigation by providing a research question and explaining the investigation procedure. Here are some sample research questions: "What species of finches have you found on the Galapagos Islands?" and "When comparing the different species of finches, how do they differ and how are they similar? Why?" After presenting the questions, teachers guide students to form a hypothesis to answer the research question: "If we observe all species of finches found on the Galapagos Islands,

FIGURE 4 Student spreadsheet used to log, organize, and compare multimodal information



we should notice morphological differences in these finches, because food availability is different on the various islands."

We suggest teachers have students choose three finches to investigate from the following list (Jackson 1994). The finches on this list have very different beaks, which helps students easily identify and compare the differences in ecology from the morphology of various species of finches, especially the shape of the beaks.

- Large ground finch
- Medium ground finch
- Small ground finch
- Sharp-billed ground finch
- Cactus finch
- Warbler finch
- Woodpecker finch
- Small tree finch
- Large tree finch
- Vegetarian finch

Step 2: Locate information

Next, students use the free and credible cyber database ARKive (see Resources) to locate specific information about the species they picked. Students should look for the following information for each specific finch species: common name, genus and species, environmental niche (terrain), Galapagos Islands location, food sources, and images of the terrain and finch. They should use a spreadsheet to organize, present, and compare the information, including text and graphic information (Figure 4).

Step 3: Organize and present information

Next, students need to locate the range of the chosen finches on the Galapagos Islands; ARKive is particularly helpful in doing so. For example, if students enter the words "vegetarian finch" on ARKive to locate the species, they will discover that "the vegetarian finch is endemic to the Galapagos Islands, where it occurs on the islands of Isabela, Santa Cruz, Fernandina, Santiago, San Cristóbal, Floreana, Marchena and Pinta" (ARKive). Then students use Google Earth to locate these islands and create "placemarks" to pinpoint the locations of these islands where the specific finch is found.

Students continue the investigation until they have a Google Earth map documenting the locations of all three finches they chose to investigate (Figure 5). They should be advised to use placemarks with different colors to represent the different species. The final result provides a model that will allow students to demonstrate the relationships among the species they chose and their habitats.

Step 4: Draw conclusions

After students collect all of the data and map information they need, they can compare habitats of the different finches they chose to study, and then draw inferences based on findings of morphological adaptation, speciation, niche partitioning, and species ecology. The geotagged photos help students learn the geographical environment of each island, understand the habitat of the finches they selected, and interpret how and why each species of finch adapted (Figure 6).

Depending on students' learning progress, teachers can ask them to annotate the habitats of each species using placemarks or record a narrated video that explains their findings in the visual format through Google Earth's built-in video-recording feature. Google Earth's placemarks are compatible with text, images, and videos. Students can use multimodal information to present the evidence they found and back up their arguments based on Darwin's theory of evolution.

The Google Earth activity allows students to visualize the remote environment they are investigating in digital and multimedia format, combined with authentic scientific data. We provide a sample lab report (see Resources), which can be used as a scaffold to help students organize information and present their understanding of Darwin's theory of evolution. Teachers can revise the lab report according to their students' knowledge level.

This activity ties to the essential understanding that "over time, populations of organisms adapt to their changing environment through natural selection" (University of the State of New York and the State Education Department). The following are possible questions to facilitate a discussion:

- What is the evidence that organisms have evolved throughout the Earth's history?
- How does natural selection result in evolution?
- How do relationships among organisms influence the success (or failure) of other organisms?
- How do the resources available influence the biodiversity of an environment?
- How does natural selection influence the biodiversity of an environment?
- What are the similarities and differences among organisms living today and those that lived in the past?
- How have the environmental conditions changed in the past and how do they continue to change today?
- Why do individual organisms in a population that have favorable traits tend to increase over successive generations?
- How can the similarities and differences in inherited traits of organisms alive today or in the past be used to infer the relatedness of any two species, changes in species over time, and lines of evolutionary descent?

Classroom implementation strategies

There are many things to consider when implementing cyber resources in classroom activities. Students often have a basic understanding of how to use Google Earth but do not know the extensive capabilities that this resource offers. Teachers may need to create a lesson focused solely on how to use the mapping tool (e.g., Google Earth or Google Maps), as some students may not be able to download Google Earth on their home

FIGURE 5 Placemarks in Google Earth showing the finches a student located on different Galapagos Islands

Students can be creative in terms of presenting the information. In this example, the student used the color blue to represent the large ground finch (L), yellow to represent the medium ground finch (M), and green to represent the small ground finch (S).

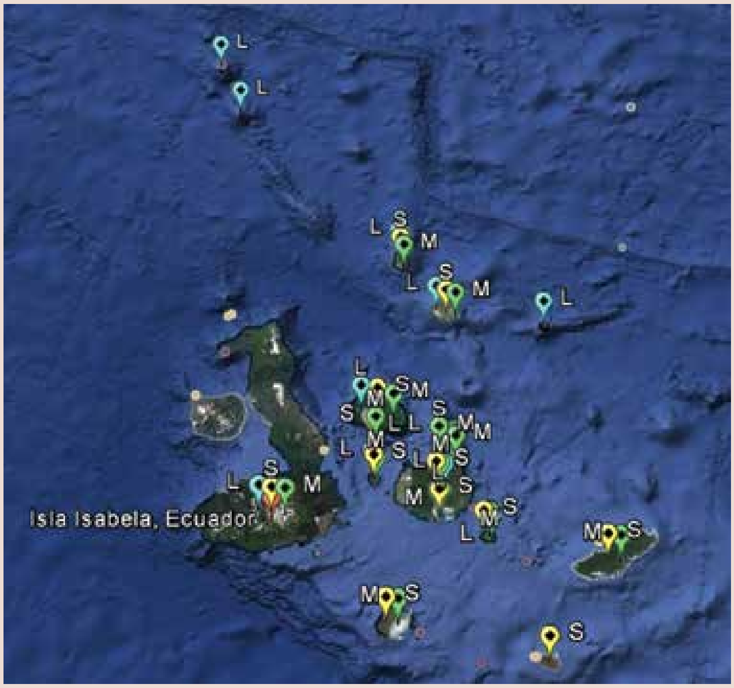


FIGURE 6 Geotagged photos help students explore the habitat through vivid images

computers. Once students master the mapping tools, they can transfer the skills to study additional science topics, such as earthquake and volcanic activities. Students can also study other species, such as the polar bear or snow leopard, to extend their understanding of Darwin's theory of evolution.

Discuss internet safety issues with students before implementing this activity and make sure students use reliable sources of scientific data when conducting research online. If your school uses class-management tools such as Edmodo or Google Site, you can upload acceptable links for students to access when doing a project as well as tutorials on how to use Google Earth, Google Maps, and geotagged photos (see Resources).

Conclusion

The integration of ICTs, historical documents, and cyber databases not only engages students in learning Darwin's theory of evolution and practicing crosscutting concepts such as patterns and cause and effect, it also teaches them how to organize and process multimodal information. The use of multimodal information is important in the science community because it facilitates scientific observation, supports the explanation of investigations, and enhances the dissemination of investigation results. Students who master the application of multimodal information also demonstrate better conceptual understanding than those who have not yet mastered it (Prain and Waldrip 2007). The integration of credible cyber databases also provides students with opportunities to conduct ongoing, real-life scientific investigations. ■

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University of the State of New York and the State Education Department. Intermediate level science core curriculum. *www.p12.nysed.gov/ciai/mst/pub/intersci.pdf.*

Resources

ARKive—*www.arkive.org*
Darwin online—*http://darwin-online.org.uk*
Darwin's Diary—www.pbs.org/wgbh/evolution/darwin/diary
Rubric—*http://goo.gl/D9yjY*
Sample lab report—*http://goo.gl/WNJnJ*

Instructional videos for Google Earth

Evolution theory: Bio diversity—Part 1—*www.youtube.com/watch?v=sKZg7tdD170*
Evolution theory: Bio diversity—Part 2—*www.youtube.com/watch?v=V6GyEOvtMO8*

Shiang-Kwei Wang (*skwang@nyit.edu*) is associate professor in the Master of Science in Instructional Technology Program and ***Hui-Yin Hsu*** (*hhsu02@nyit.edu*) is associate professor in the Teacher Education Program of the School of Education at the New York Institute of Technology in Old Westbury, New York. ***Jean Posada*** (*wizedrag@gmail.com*) is the science teacher at J.H.S. 074 Nathaniel Hawthorne School in Queens, New York.