Chapter 10: Real and Virtual Fieldwork:

"Why Does This Place Look the Way it Does?"

All the major topics in *The Teacher-Friendly Guides™* were built upon observations of the natural world, and these observations are the clues that scientists use to reconstruct the history of the Earth. Shelly fossils along the Himalayas tell of ancient sea floors that have been uplifted into mountains. Ripple marks that have since turned to stone tell of ancient shorelines. And scratches along the bedrock in Central Park tell of massive glaciers that—some 20,000 years ago—created a skyline much different than the one of steel and glass found in New York today. A number of forces and processes have made seas, forests, deserts, and the life those ecosystems hosted appear and disappear from the landscape over the course of geologic time. Many of these changes left behind hints that we can interpret today when we tell the story of a place. That massive glaciers once advanced as far south as New York is not a conclusion derived from mathematical modeling in a lab; it is instead evidenced by not only those scratches, but also by a host of observed glacial deposits that litter not only New York, but much of northern North America.

> *The story of a place is written in its landscape, rocks, fossils, and biota; fieldwork investigations help scientists—and students and teachers—tell that story.*

Introducing students to the practice of fieldwork can be a tremendous experience. Its central role in the education of geoscientists makes fieldwork a "signature pedagogy" in the preparation of professionals within the field, and fieldwork warrants a larger place in the K-12 curriculum. For these reasons, real and virtual fieldwork practices are well suited for addressing both *The Next Generation Science Standards* and *The Common Core Learning Standards.* Fieldwork as a topic is also fundamentally different from the other chapter topics in this guide. Therefore, this chapter is somewhat different in structure and is significantly longer than the other chapters in the Guide. The chapter begins by laying out some of the rationale for engaging in real and virtual fieldwork, and it then addresses some of the nuts-and-bolts issues for planning, carrying out, and documenting fieldwork with your students.

Exploring local natural history through inquiry-based approaches emphasizes critical thinking. And by conducting such investigations, students have taken a tremendous leap: they are not merely learning about science; they are doing science! But getting students into the field can be difficult. An alternative is for the educator to visit the field on his or her own time, returning to the classroom with a series of images and specimens that permit a Virtual Field Experience

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(VFE). Virtual fieldwork offers the opportunity to explore an area without leaving the classroom, and it allows multiple "visits" to a site. VFEs can also enhance and extend the experience when actual fieldwork is possible. The Earth is a system, after all, and any one site—virtual or real—can display a host of natural phenomena, from simple erosion and deposition to the principles of superposition and faunal succession to the formation of ripple marks or mud cracks. By adding to a VFE year after year, you can also document changes within the environment, such as changes to a stream's course, the succession of an ecosystem, or the nature of human disturbance. Ideally, virtual fieldwork in the classroom captures the active experience of a scientist examining an area: It provides opportunities to actively explore, discover, ask questions, and make observations that help to answer those questions, ultimately allowing students to develop educated responses to the question *"Why does this place look the way it does?"*

Commonalities of Virtual and Actual Fieldwork

This chapter addresses both actual and virtual fieldwork and the many connections between them. The process of making VFEs, at least in the ways we lay out here, involves doing actual fieldwork. Much of the work of making a VFE involves simply following good fieldwork practices in combination with a heightened attention to sharing the experience with students or other learners. While VFEs can be used in place of actual fieldwork, they can also be used to both prepare for and reflect upon actual fieldwork. Engaging students as partners in the creation of VFEs is an opportunity for teaching through inquiry while also building a resource that is useful to people outside of the school, as well as to future students. What follows addresses all of these possibilities.

NASA scientists routinely conduct actual fieldwork remotely.

We also draw attention to the distinction between field*work* and field *trips*. We strive to engage learners in *figuring things out*, while field trips—whether actual or virtual—are too often characterized by trip leaders *pointing things out*. Building in the opportunity for genuine discovery is challenging but promises to yield longer-term engagement and understanding.

Just Go (and Don't Stop)

The minimum requirement for conducting fieldwork is your own sweet self. This chapter discusses a wide range of tools and approaches, but doing fieldwork of any (safe) sort that doesn't damage the site is a key objective. The tools and approaches discussed in this chapter will extend your senses and help you to capture the experience in ways that will make it easier to share with students. Work within your comfort zone (but perhaps at its edge) and at a pace appropriate to what life allows, and gradually build your virtual representation of the local environment over the course of years, increasing student participation in the process as time goes by. Use the local landscape to nurture skills within your students that will allow them to read any type of landscape. Through this process, your students can teach members of your community about the story of your site while also creating and extending resources that can teach other learners around the country about where you live. Building a deep understanding of place through VFE development and then comparing your local environment with VFEs created by other teachers and students is an excellent way to use the local environment to understand the global environment.

Whether the fieldwork is real or virtual, it can either involve a single visit or be extended over many, many visits. Scientists may reach points where they have figured out particular pieces of the puzzle when understanding the nature of a site, but they never fully understand all aspects of a place's story. Fieldwork, therefore, is something that is never "finished." Whether it is the second or seven-hundredth visit to a site, there is always more to discover. This is part of what makes science fascinating! It connects to the idea that while fieldwork may focus primarily upon a single topic, researchers (whether K-12 students, educators, or professional scientists) who develop a deep understanding of the story of a place must understand the roles of geology, ecology, climatology, anthropology, and more. Of course, this type of understanding will not come from a single class period of fieldwork, or even a single course infused with fieldwork, but the appreciation of this systems idea can be planted and nurtured.

Start local

In choosing a field site, whether it is local or distant or for actual or virtual fieldwork, it should be interesting from an Earth systems science perspective. Fortunately, if you know how to look, *every* site is interesting from an Earth system science perspective. Over the grand course of Earth history, the story of any location is a fascinating one that involves myriad changes. The work of telling the story of any environment is a form of rich inquiry. While it would also be fascinating to find a place that hasn't changed, no such place exists on the surface of Planet Earth!

While VFEs provide the opportunity to study distant or otherwise difficult to access locations, we suggest starting close to home or school, at a location that students are already familiar with or have access to. What is outside your classroom door has more immediate relevance to the lives of your students than anywhere else on Earth. Nearly every unit in an Earth or environmental science course, and most of the units in a biology course, play out in some meaningful way in the local environment, and the local environment can extend the boundaries of the classroom tremendously with little or no cost. Things are only understood in comparison to something else, so comparing sites to one another can deepen one's understanding of both or even of all sites—but it is still best to start with the local.

Students can use real or virtual field sites to study how all the major topics in their Earth or environmental science curriculum are manifest in the "real world." In an ideal situation, the classroom is immediately adjacent to a safe, accessible field site, and there is flexibility within the school schedule that allows for in-depth study of the site in ways that cut across disciplinary boundaries. Unfortunately, it's not always practical to repeatedly visit an actual field site with 30 students throughout the year or semester. Through virtual fieldwork, students can come to see how the rock types and flora and fauna outside their classroom tell part of the story of that place.

In order to create VFEs, authors must closely study their field sites with an eye toward doing fieldwork with students. VFEs are a stepping-stone to bringing students into the field, even if the field is "only" the schoolyard. VFEs can be used to prepare students for the field and/or to process the fieldwork after visiting the actual site. Ideally, students will participate in the creation and extension of VFEs, but we recognize that getting to this point may take years.

Connecting to Earth Science Bigger Ideas, the Next Generation Science Standards, and the Common Core

Fieldwork investigations have the potential to be extended indefinitely in time and can involve the integration of a wide range of science and non-science disciplines. *"Why does this place look the way it does?"* is a bottomless question, meaning that it can be productively investigated for a very, very long time. Field scientists, be they professionals or fifth graders, will never fully answer this driving question absolutely or at every scale.

The act of VFE creation is a valuable type of professional development (PD) that creates useful evidence of having done the PD. Through the creation and continued use of virtual fieldwork, a teacher can become a true expert on his or her local environment—perhaps the preeminent expert. The process of VFE creation and use can also create evidence of inquiry teaching aligned to relevant standards. The VFE you create or augment can serve as a key piece of a professional portfolio.

The ultimate goal of our instruction is to build understanding of the Earth system and the ways in which science is used to build that understanding. We bring focus through the use of a small set of bigger ideas and overarching questions. These are discussed in detail in the Big Ideas Chapter and are also summarized below.

Overarching questions:

- How do we know what we know?
- How does what we know inform our decision making?

Earth system science bigger ideas:

- The Earth is a system of systems.
- The flow of energy drives the cycling of matter.

- Life, including human life, influences and is influenced by the environment.

- Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system.

- To understand (deep) time and the scale of space, models and maps are necessary.

Fieldwork should provide the opportunity to explore, describe, and build understanding of these questions and ideas. These ideas and questions map onto the *Next Generation Science Standards'* Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices. The Crosscutting Concepts and Scientific and Engineering Practices are shown in *Table 10.1*. As you read through the rest of this chapter, and as you and your students carry out fieldwork, revisit these lists of concepts and practices frequently in order to draw attention to how they connect to the work of reading the landscape.

Table 10.1: NGSS's Scientific and Engineering Practices and Crosscutting Concepts. As you and your students engage in fieldwork, consider how the practices and concepts are being used to make sense of the environment. See the Big Ideas Chapter for a more in-depth discussion.

Scientific and Engineering Practices	Crosscutting Concepts
1. Asking questions and defining problems	1. Patterns
2. Developing and using models	2. Cause and effect
3. Planning and carrying out observations	3. Scale, proportion, and quantity
4. Analyzing and interpreting data	4. Systems and system models
5. Using mathematics and computational thinking	5. Energy and matter
6. Constructing explanations and designing solutions	6. Structure and function
7. Engaging in argument from evidence	7. Stability and change
8. Obtaining, evaluating, and communicating information	8. Interdependence of science, engineering, and technology
	9. Influence of engineering, technology, and science on society and the natural world

Fieldwork Challenges and Benefits

Of course, VFEs also allow for some kind of "fieldwork" experience when actual fieldwork is difficult or impossible to carry out. The reasons that actual fieldwork is difficult are fairly obvious:

- **Fieldwork is logistically challenging.** It's hard to fit into a typical class period, or even a double lab period. To go off site requires permission slips, busing, and figuring out how to deal with behavior outside the normal classroom setting.

Challenges

- **It costs money.** Field trip budgets have been slashed, and weren’t even very common at the secondary level before budget cuts.

- **Many teachers have only limited experience doing field science themselves.** Earth science has more teachers teaching out of field than any other science discipline, and fieldwork is not a component of many Earth, biology, or environmental science teacher certification programs. It is intimidating to lead fieldwork if you haven’t been through it yourself.

- **Fieldwork poses safety and behavior concerns different from those in the classroom.** Falling off a cliff has different consequences than falling off a chair.

- **Teaching in the field employs a different set of skills than teaching in the classroom.** The logistics of moving groups of students from place to place and focusing their attention on the goals of the fieldwork takes careful planning, especially if multiple classes are involved.

These issues shouldn't preclude fieldwork, but they undeniably complicate it. These challenges are not insignificant, but the rewards of doing fieldwork are worth the trouble. Field trips are among the most memorable and most valued school experiences.

Fieldwork 101: Gathering Information and Creating Your Own VFE

What follows are recommendations. These recommendations are intended to help prepare you for fieldwork, but they are just guidelines, not steadfast rules. Bringing the field to the classroom at any scale is better than not bringing the field to the classroom at all. The careful attention to detail described here will prove extremely helpful, but avoid being discouraged if your first trip to the field isn't as productive as you had initially imagined. Scientists of all disciplines continually refine their methods and procedures, leading to more productive and "better" results over time. With time and more fieldwork, your confidence will grow. Get into the field, be safe, and do your best to capture the experience in a way that allows you to best reproduce it for your students!

Fieldwork 10

Fieldwork 101

Before visiting the site: understand the natural history of the region

In order to make sense of a local site, it's helpful to understand the geologic history of the larger region before your visit. Did inland seas once flood the area? Have mountain-building events shaped the landscape and its rocks? Was it glaciated? Since the reasons that a place looks the way it does are dependent upon more than the geology, you want to pay attention to this concept as well. That being said, since the geology is the base upon which the landscape is built, starting there makes good sense. *The Teacher-Friendly Guides*™ are an excellent source for discovering the history of a region, as well as that history's effect on the rocks, fossils, and other features of the area.

Questions to Keep in Mind

When visiting or examining any area, the ultimate question to answer is: *Why does this place look the way it does?* But to help understand such an overarching concern, it is important to have certain other questions in mind. These questions will guide exploration, and they will help ensure that important information is recorded during your visit:

- What kind(s) of rock(s) are found in the area? How do you know?
- In what environment did these rocks probably form?
- What is the arrangement of the rocks?
- Are fossils preserved in the rocks? If so, what can they tell you about past environments?
- What has happened to this area to make it look the way it does today? (That is, what has happened to the area since the rocks formed?) Why do you think so? (What is the evidence for your claim?)

We have put together a set of questions that build upon the fundamentals listed above and that can be asked of any site. This is a key idea—that there are questions that can be asked productively about any environment. Recognizing that idea is a key step toward being able to take the lessons of one field trip and applying them to the "reading"of any landscape. These questions are included in the graphic organizer in *Figure 10.1*, and as a checklist in the section entitled Back in the Classroom.

Fieldwork

Fieldwork 101

Figure 10.1: This pair of graphic organizers shows various paths of inquiry that stem from the question: Why does this place look the way it does? *The top graphic focuses upon the geosciences, and the bottom focuses upon the environmental sciences. The questions within the diagrams are also included as printable checklists in the section "Back in the Classroom."*

Safety and Logistics in the Field

At the Site

Considerations are different for an adult or a group of adults in the field than they are for taking students into the field, but certain measures related to safety are universal. At any field site, safety is the first priority. No photograph, measurement, or fossil is worth the risk of personal injury or death. To ensure safe and productive fieldwork, keep the following thoughts in mind:

- Always carry a small, standard first-aid kit.
- Wearing the proper clothing is very important. Long pants are recommended, as are sturdy boots, which will help prevent twisted ankles as you scurry over uneven or loose surfaces.
- While walking through a valley or next to any outcrop, always be on the lookout for rock falls. Remember, slopes with no vegetation tend to produce more falls.
- If more than one individual is climbing an outcrop, do not climb single file. Rocks dislodged from one climber can quickly tumble down the outcrop and hit the next climber.
- When using your rock hammer, protective eyewear should always be worn. If your hammer possesses a sharp pick opposite the flat surface, always use the flat surface when striking. And if you are working with others, notify all in the vicinity before striking any surface with your hammer.
- Never use one hammer to strike another. Metal chips can be broken off and thrown at high speeds.

Sunscreen, insect repellent, flashlights, food, and water should be considered in relation to environmental conditions and length of the field excursion. Please note that this chapter is written with shorter excursions in mind where substantial supplies will not generally be required. The next section offers more detail on the materials to take with you into the field.

Give appropriate consideration to group management. We suggest taking individual classes into the field for short trips before attempting either longer fieldwork excursions or trips with multiple classes. Managing larger groups or longer trips requires attention to logistics that will not be addressed in depth here. Whether the group is large or small, consider the benefits of a buddy system and measures to keep track of where everyone is—both children and adults. If groups are spread out on the trail, the lead group should stop at trail crossings to make sure everyone follows the intended trail. Younger students should not be left unsupervised for *any* length of time. Schedules and rendezvous points are important for longer trips and larger groups. All teachers and chaperones should have one another's cell phone numbers.

10 Fieldwork

Needs

Things You Might Use in the Field

The Essentials and Near Essentials

As noted above, the essential materials for going in the field (besides yourselves) are clothing (especially footwear) that is suited to the weather and trail conditions and a first-aid kit appropriate to the situation. You will likely also want tools or devices to extend your senses, to preserve your observations, to collect materials (where safe and legal), to take photographs, and to store data, all of which will allow for continued observation and analysis after you return from the field. If your fieldwork is on the school grounds, or adjacent to it, you perhaps won’t need anything different than what is needed on a typical class day, at least for the initial visit.

To extend your senses, start with simple things like magnifying loupes and rulers and potentially move on to include more sophisticated tools like probeware (to measure pH, temperature, and dissolved oxygen) or field microscopes. Since tools are used for both extending your senses and for capturing and preserving your observations, the most obvious tools for preserving one’s observations are notebooks, pencils, cameras, GPS units, smartphones, and tablets.

As varied as field science is, a few items should be in every scientist's gear whether you are investigating rocks, observing streams, or documenting ecology. Even though processes and concepts are universal, each place is also unique, a product of its position on the Earth, its geological and ecological history, and the local human impacts. Making sense of why a place looks the way it does must take that context into account. Further, good science depends upon repeatability of observations: if another scientist (or your next class!) wants to analyze or build upon your observations, he or she must be able to know precisely where your study took place and how you made your observations. It is thus critical to locate the position of your studies on a map as precisely as possible. With modern GPS technology, it has never been easier to record a location to within a few meters, though you can certainly follow good science practices even if you don’t have this capability. *Table 10.2* lists equipment and materials that are useful in the field.

Maps and Notebooks

Large-scale maps provide a way to see your field site in the context of other features in the area. At a closer scale they also provide a way to show the position of several sites relative to each other. At still higher resolution, maps provide the medium to store and display spatial information from one site. You will therefore probably want maps at all of these scales.

Large- and medium-scale maps for providing context can be found online. Google Maps and Google Earth are two of the best known interactive sources. If students need help understanding maps and scale, a helpful exercise is to create a "Powers of Ten" map of your schoolyard, starting with an overhead shot of the school yard that students recognize, then zooming out—making each of the new images increase in dimension by ten times—until one can see the site from the perspective of the whole Earth. A video tutorial, inspired

Table 10.2: Materials to take in the field. (Items in bold are highly recommended.)

For Safety and Comfort	For Extending the Senses	For Preserving and Extending Observations
☐ **Yourself** ☐ **Appropriate footwear** ☐ **First aid supplies** ☐ Water ☐ Sunscreen ☐ Insect repellent ☐ Food ☐ Safety goggles ☐ Flashlight ***Common sense** should be your guide when determining what is needed for a particular visit to the field. Trips that last a class period and are adjacent to the school may require nothing beyond materials for a typical class—a notebook and a pencil.*	☐ **Ruler or scale card** ☐ Measuring tape or meter stick ☐ Magnifying loupe or hand lens (about 10× magnification) ☐ Water test kit ☐ Compass ☐ Clinometer ☐ Field microscope ☐ Field guides	☐ **Notebook** ☐ **Pencil** ☐ **Materials for collecting** o Baggies o Specimen labels o Sharpies ☐ Rock hammer ☐ Camera

For Both Extending the Senses and Preserving Observations
☐ **Maps** ☐ **Camera** (possibly with video) ☐ Probeware and interface (like the Vernier LabQuest) ☐ Digital field microscope ☐ GPS unit, smartphone, or tablet ☐ Apps used in the field might include: o GPS o Google Earth or other virtual globe o Skitch (or other image-annotating app) for adding notes to photos. Skitch also includes a map annotation function. o Photosynth or other panorama app o Video (the YouTube Capture app allows for basic video editing on your smartphone or tablet) o Other specialized photography apps o Audio recorder o Notes o Photo management software, such as Web Albums

by the classic film, is available at http://www.virtualfieldwork.org. It is simple to add your field site to the same Google Earth file containing the Powers of Ten centered on your school. This can help students better understand the location of the field site in relation to the school.

Field scientists typically show information about their field site: the location of observations (such as photographs and specimen collection) and also the scientific data (such as rock type, position of faults, areas of bedrock exposure, water quality information, and much more). For these purposes you may want to have a paper copy of a map you can bring into the field upon which you can make notes. Commonly topographic maps are used as base maps, in part because the contours can help you locate yourself on the map (if it's not completely flat) and partly because the topography itself is often relevant to Earth and the environmental data being collected. If your field area is larger than about 100 meters (330 feet) on a side, you can create a topographic map tailored to your needs using online software (http://www.gpsvisualizer.com). USGS topographic maps of the entire US are available as free downloads at http://www.usgs.gov/pubprod/. You may wish to download the local map and take an excerpt of the area surrounding your site.

10 Fieldwork

Needs

Positions of samples, photographs, and observations can be located using GPS. In this case, you can make notes about your GPS locations, and plot the locations on a computer later, or make use of an app like Skitch that allows you to annotate digital maps in the field. Photos taken with smartphones, tablets, and GPS-enabled cameras will include location data with pictures. Those familiar with Geographic Information Systems (GIS) can make elaborate maps using your own sets of coordinates and data. While GPS and GIS technology are now standard in most types of fieldwork, they are not essential for doing good fieldwork. Standard, intuitive tools for measuring are, however, quite helpful. A compass (either traditional or digital) can be helpful in orienting your field site in space, and a ruler and protractor can be helpful when drawing the field site in correct proportions (e.g., the position of samples along a transect or the angle of bedding or faults). Bring a clipboard so that you have a flat surface to write upon in the field—pencils and a good eraser are the best writing implements for drawing and annotating your map.

It is possible in principle to capture all your data electronically, but most field scientists still use a notebook even if they have access to the latest technology. Certain information can be captured very simply in the field with a pencil and paper while it may prove challenging with digital technology, such as when making annotated sketches of the field site and taking written notes. Normally pencil is used, in part because it doesn't smear if it gets wet, but also because it's erasable; while not essential, field scientists who know they may have to work in wet conditions will purchase notebooks with waterproof paper (Rite-in-the-Rain notebooks). An audio recorder (smartphone or standalone digital recorder) is handy when writing a lot of text is impractical, though it does create transcription work at the end of the day. Remember that it is considered a form of "best practice" to make sure that each entry includes the date, time, and locality.

Documentation and Specimen Collection

Photographs

Once at a field site it is easy to immediately begin taking photographs without recording notes to accompany them—a problem experienced by professional and amateur scientists alike. But the lack of proper documentation is perhaps the most common mistake made in the field, especially with digital photography, where it is easy to take tens or even hundreds of photographs at a single site. Also, before you begin photographing it is advisable to first explore the entire location and develop a plan for how you will communicate the site to your students back in the classroom. This plan will guide your photography, and the recorded notes will ensure that every image makes sense long after you've visited the site. Proper documentation includes the following steps:

- Note the location and orientation of the photographs you take. Recording this information on a map is very helpful.

- In each photograph, it is important to have a sense of scale. For smaller structures (like ripple marks or fossils) or close-ups of an outcrop or rock, it is important to show scale by using a common object, such as a penny, rock hammer, an unsharpened pencil, or (ideally) a clearly marked ruler. For larger structures, a really great scale is a person, so feel free to step into the picture! The importance of a scale cannot be overstated, as the proper identification of geologic features in photographs often depends on knowing the feature's size.

- In addition to showing scale within photographs, be sure to pay attention to different scales across the set of photographs you take. That is, include photographs across a wide range of scales, from the smallest fossil or mineral crystal to panoramic shots of the landscape. Maps and virtual globe software, such as Google Earth, can extend scales from the local landscape to a global perspective.

Drawings

Although photographs are key, simple sketches or drawings are also useful for documenting a field site. In fact, subtle changes in rock layers, for example, may not be visible in photographs, so to capture such features, drawing may be required. Drawing also forces you (or your students) to observe closely. It will be helpful to use either a Rite in the Rain notebook or a large, clear plastic bag to hold your notebook in case of rain. When drawing, keep in mind that you should document the same type of information that is documented in photographs (location, orientation, and scale). Drawing also requires close study in a way snapping a photograph does not. Louis Agassiz once said that "…a pencil is one of the best of eyes." While drawing, you have to think about the relationship of the elements you are representing, their scale, and their arrangement.

Annotating Photographs

The use of smartphones and tablets in the field allows for a hybrid of photographs and drawings. Many apps allow for captioning photos in the field, and some allow you to draw and write text on photos as you take them. Skitch is one such app, and it also allows for the taking of notes on the maps themselves. Photos taken on smartphones and tablets are also (typically) geo-referenced. This means that they can easily and quickly be included in a Google Earth or other GIS program in the precise location where the image was taken. If you are unable to annotate photographs in the field, or you wish to add more detail than is practical on your electronic device while you are at the field site, the "old fashioned" technique is to take a picture, then make a simple notebook sketch containing labels of key features. Later you can annotate a digital or printed version of the photograph using your field notes. If the conditions are poor for note taking either digitally or manually, it may be more practical to record audio notes that you can later match to your picture.

Using Field Guides

Select field guides appropriate to the focus of your work and consider whether or not you wish to bring others. The appropriate field guide might be something as simple as a single sheet with line drawings of the fossils common at your field site, a few pages containing a dichotomous key of common rock types, or a collection of field guides on fossils, birds, mammals, butterflies, rocks, flowering plants, and more. While scientists will come to know by sight the kinds of specimens commonly found at their site, they do not typically set out to memorize them, and uncommon things are sometimes found that send even experts back to their field guides.

Collecting Specimens

Rocks and fossils often provide significant clues for interpreting past environments. Layers of basalt indicate past volcanism, for example, whereas shales bearing trilobite and other fossils indicate deposition in a shallow sea. Collecting specimens from a site provides a wonderful opportunity to take a piece of the field into the classroom, allowing you to engage students in hands-on learning. Collecting specimens also permits further study away from a site where time and field conditions can impose certain limitations. You can and are encouraged to identify rocks, minerals, fossil types, and flora and fauna in the field. So, what do you need to know about collecting specimens?

- **You first need to confirm that collecting specimens at the site you are visiting is legal**. Typically, collecting is not allowed in parks, so be sure to check.

- Just as you made decisions about photography based on how you plan to communicate the site to students, collect specimens that will help tell the story of the site back in the classroom. If rock types change from area to area, either vertically or horizontally, then specimens of each type are ideal.

- Before collecting a specimen, take a photograph of it in situ, both close up as well as from a distance. Don't forget to include an object for scale in the photograph!

- Document the location from which the specimen is collected, preferably on a map of the area. Labeling the specimen with a number that corresponds to a number on your map is an effective technique.

- Specimens should be broken directly from the outcrop so the exact source is known. Eroded rocks scattered about on the floor of the site may have originated from multiple locations.

- The weathered surface of rocks often carries a different appearance than a "fresh" break. Ideally, collected specimens possess one weathered surface but are otherwise not weathered. Rocks broken directly from outcrops will ensure fresh surfaces.

- As specimens are collected, place each in a separate resealable bag, noting on the bag with permanent marker each specimen's location as indicated on your map. Include a specimen label within the bag, including the information shown in *Figure 10.2*.

PALEONTOLOGICAL RESEARCH INSTITUTION

ReaL Earth Inquiry Specimen Label

Location rock was collected:

Kind of rock or fossil:

Geological period or age of rock:

Collector:

Date collected:

Figure 10.2: This specimen label, printed six to a page, is available for download at http://virtualfieldwork.org/Assessments_and_Student_Materials.html.

Back in the Classroom: Virtual Field Experiences (VFEs)

Following your trip to a field site, perhaps the most critical step after returning to your lab or classroom is to examine all of your photographs, illustrations, specimens, and notes associated with each. Sometimes even the most diligent geologist forgets to record notes that, in hindsight, are critical. It is therefore recommended that one makes sure that his or her notes are legible and complete. Recopy your notes. Such an activity will not only ensure legibility for the future, but it will help indicate any gaps in your note taking. If gaps exist, then it is easiest to fill them in when your memory of the site is fresh.

Once your materials from the site visit are in order, it is time to develop an activity that will allow your students to experience the site much like you did—but in the classroom. VFEs allow you to compile this information in a way that is easy to share with others who wish to learn about the site. Ideally, VFEs provide opportunities for open-ended exploration, just as actual fieldwork does. Scientists in the field are not limited to a single possible way to operate, nor do they have a guide explaining what they see at every turn. In the field, one might pick up a rock and take a closer look, or pull out a magnifying glass and look at a cliff face. Exploration drives inquiry in the field, and inquiry and exploration are key goals of VFEs.

The concept of VFEs can take on multiple forms. For example, kits containing maps, printed photographs, and specimens (with notes on the map indicating where the specimens were collected or where the photographs were taken) can be produced. Or, your digital photographs can be embedded within a PowerPoint or Prezi presentation, a website, or a Google Earth tour with placemarks containing photos, video, or other data in the exact locations where the specimens were collected. Maps can also be overlain. Historic maps can be included, and Google Earth has historical imagery included for much of the world. Many VFEs incorporate more than one technological platform.

Keep in mind that these electronic presentations may take on a very linear, directed feel. In that respect, be careful that your VFE does not turn into a Virtual Field Trip. Virtual Field Trips have become increasingly common at many levels of education, but these experiences are typically guided tours rather than opportunities for inquiry. An online search will yield many examples of these tours, as will a search of the Digital Library of Earth System Education (DLESE). Such resources clearly have value, but they are passive experiences for students. VFEs, in contrast, should stress the importance of inquiry; learning for understanding involves students figuring things out. The act of making new, or extending existing, VFEs may be the simplest way to bring inquiry to the use of VFEs.

In considering VFEs as a recurring practice, initial experiences are perhaps more guided than the later experiences; allow a gradual transfer of responsibility from teacher to student. But VFEs ideally offer the same opportunities for exploration as those provided at an actual field site, with occasional moments of discovery that lead to new questions about the site. By asking such questions and then seeking answers, students are doing science. And it is perfectly reasonable to virtually visit a site several times for further data collection, or even to study different concepts at the same site. Scientists, of course, do exactly the same thing.

Prezi and PowerPoint VFE Templates

This section discusses templates intended to simplify VFE production in addition to providing general information on VFE development and use. There are templates in both Prezi and PowerPoint formats, each with a version of the graphic organizer shown in *Figure 10.1* as its centerpiece. Questions in the graphic organizers and in the rest of the templates are written generically, so they may be applied to any site. The templates serve as starting tools that are useful for creating an "entry level" VFE. They are available at http://virtualfieldwork.org/Template.html. The template includes graphic organizers for both Earth and environmental science, with the environmental science organizer embedded within the geoscience organizer.

How are teachers using virtual fieldwork?

VFEs might be used as a single, in-class exercise, or they can be explored across an entire year. We hope that teachers who use and develop VFEs will eventually use them across the entire curriculum, but it makes sense to start smaller. There is no single correct approach to using VFEs in the classroom. Here are some examples of ways teachers are using virtual fieldwork:

- Students in a rural community are using Google Earth to create Powers of Ten tours centered on their homes (based on the Eames' classic film). This helps students to internalize the abstraction that is central to making maps and to build deeper understandings of scale.
- Students are making geologic maps of the local bedrock.
- Students are creating an interpretive guide for a county forest.
- Students are exploring lakes, dams, streams, outcrops, quarries, waterfalls, and more.

For more VFEs, see our growing database at http://virtualfieldwork.org/.

What do I need to consider as I begin to build my VFE?

Considerations fall into four categories:

- **Logistical:** What do I have the attitude, time, resources, and skills to do? (Attitude is listed first as it is the most important factor.)
- **Pedagogical:** How do I bring the scientific content together with technologies in a way that best builds enduring understandings of bigger ideas and overarching questions, as well as of the smaller scale ideas and questions I deem important?
- **Technological:** What hardware and software do I need to assemble the materials for the VFE and to make it accessible to my students? This may include traditional scientific tools, like a rock hammer or a compass, as well as the computer technologies discussed in this chapter and on our website.
- **Content:** What scientific knowledge, ideas, processes, and practices do I want my students to understand and be able to do at the end of the experience?

Of course, these categories overlap and interplay substantially—teachers of Earth science use Google Earth in different ways than other Google Earth users do.

Most of the remainder of this chapter is a set of checklists to help you address these different considerations when outlining your VFE design. Take it with you into the field as you collect pictures and other kinds of data for your VFE; use it to identify issues you think are most important for the development of your VFE. Most of the items in the checklists are there to start you thinking about how to address a particular issue. Content is listed last for the sake of readability, as the checklists for the content section are longer than they are for the other categories.

The framework for understanding how to effectively blend technology, pedagogy, and content knowledge is known by its acronym TPACK.

Table 10.3: A checklist of cross category issues. Many of the questions in the checklist relate to more than one of the categories identified above. Because of this overlap, only the cross-category issues and content sections are of significant length.

Have I considered this?	Question:	Logistical	Pedagogical	Technical	Content
	Do I have appropriate safety and first aid equipment and materials?	√		√	
	What content do I want to address?	√	√	√	√
	Do I have connections in mind to at least a couple of the bigger ideas and overarching questions? • The Earth is a system of systems. • The flow of energy drives the cycling of matter. • Life, including human life, influences and is influenced by the environment. • Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system. • To understand (deep) time and the scale of space, models and maps are necessary. • How do we know what we know? • How does what we know inform our decision-making?		√		√
	How much time do I realistically have to spend on VFE creation?	√			
	How much class time do I want to dedicate to VFEs?	√	√	√	√
	Am I okay with the trade-off between some expected frustration and the pedagogical payback?	√	√	√	√
	Can I productively engage students in VFE development? *Or is that something to aspire to for next year?*	√	√	√	√
	How does the technology I have serve the goals I wish to meet?	√		√	
	Do I have enough batteries for my powered equipment?	√		√	
	Is the site accessible to me? *This includes legal, safety and proximity considerations.*	√	√		
	Are my students familiar with the site? If not, is it accessible to *all* of my students? *If the answer to both questions is no, select another site.*	√	√		
	Are the required pedagogical, technological, and content skills and knowledge needed to create the VFE within my reach? *Ideally, select challenges that are just within (or just beyond) your reach so that you grow professionally.*	√	√	√	√
	Do I have the hardware (including field equipment) and software needed for VFE creation? *The bare essentials are an Internet-connected computer, a digital camera, and either PowerPoint or Google Earth.*	√	√	√	

Logistical

We hope that VFE development is used to expand teachers' skills and knowledge. Performing fieldwork for the first time can be overwhelming, but remember that science is a process, and not even professional scientists capture all that they need in one visit. With practice, and the proper attitude, you will become more and more comfortable when visiting the field.

Pedagogical

While most pedagogical questions also address other categories as noted above, there are issues that deserve explicit attention here.

- Does the data you are collecting go toward answering why this place looks the way it does? *Or is there a good reason to introduce distracting information?*

- If the site is especially striking or unusual, have you considered how to get yourself and your students beyond the "novelty space" of the location? Crudely summarized, novelty space is the idea that you can't figure out what's going on at a field site if you're either awed by its beauty or freaked out by its perceived dangers. This is one of several reasons for choosing a site that is already familiar to the students.

Technological

Most technological issues are also logistical; these are addressed in the table above.

Content

Why does this place look the way it does? The driving question of our work can serve as an entry into any major topic in Earth or environmental science curricula. It also brings relevance to the science since we want to start with sites near the school that are already somewhat familiar to the students. We want students to look at the familiar with new eyes, and to become skilled at reading their local landscape. Ultimately, we want the skills built by reading the local landscape (being able to tell the story of why a place looks the way it does) to be transferable to *any* landscape.

What scientific content do you want your students to better understand through their work in the VFE? How does this fit into the larger goals of the course? Can you draw, and help your students to draw, connections to bigger ideas and overarching questions? What topics in Earth science can be addressed by doing fieldwork?

Understandings will be made much deeper in schools where teachers in more than one subject or grade level engage their students in studying the local environment.

Below are questions taken from the geoscience and environmental science graphic organizers. Most teachers will likely use one sheet or the other, but not both. Your VFE likely won't address all of the questions (on either sheet), but you should be able to strategically select what you minimally wish to address.

VFEs

For the Geosciences:

For all of the following questions:

- How do you know? (What evidence is there?)
- What does it tell you about past environments?
- What does it imply about the future?

☐ **Describe the shape of the land.**

- Are there mountains, valleys, or hills?
- What are the valley shapes?
- What can cause valleys to form?
- What can cause mountains or hills to form?
- Are the mountains or hills young or old?
- What roles does tectonics play in shaping the site?

☐ **What effects has water had on the landscape?**

- Is water depositing material, eroding material, or both?
- Is the action of water primarily chemical, primarily physical, or both chemical and physical?

☐ **What effect has the climate had on the landscape?**

- Was the past climate different?
- What factors may have been affected or caused by climate?
- How has fire played a role in shaping the environment?

☐ **Describe the ecosystem.**

- See the ecosystem graphic organizer and checklist.

☐ **What does the arrangement of the rocks and soils indicate about past conditions?**

- Do the rocks seem to form a sequence?
- Where would you find the oldest rocks? The youngest rocks?
- Does the rock record include evidence of ancient disturbances? If yes, describe.
- Are there different kinds of rocks at different outcrops?

☐ **What types of rock and soils are there and what do they indicate about past conditions?**

Sediments and Sedimentary Rocks

- Is the sample clastic or organic /chemical?
- If clastic, what is the grain size?
- If organic, what minerals is it made out of?
- Are there fossils?

Metamorphic

- Is the rock foliated or non-foliated?
- What was the parent rock?

Igneous

- Did the rock form above or below ground?
- Is it felsic or mafic?

☐ **What effects has life, including human life, had on the landscape?**

- How have plants shaped the landscape?
- How have animals generally, and humans in particular, changed the landscape?
- On what scale?

For the Environmental Sciences:

For all of the following questions:

- How do you know? (What evidence is there?)
- What does it tell you about past environments?
- What does it imply about the future?

☐ **Describe how life shapes the land.**

- What are the pioneer plants?
- How do pioneer plants impact soil formation?
- How are animals shaping the land?
- Are there invasive species? If yes, what are they, and how are they changing the ecosystem?
- Have disturbances played a role in the introduction of invasives? If yes, describe.
- How are new invasives likely to change the ecosystem over the next century?

☐ **Describe the role of water in the ecosystem.**

- In what ways does water serve or disturb habitats?
- How does life move, use, and store water?

☐ **How has climate shaped the ecosystem?**

- How is the climate reflected by living things at the site?
- Describe any microclimates and how they affect life.
- Describe how sun and shadow affect life.
- What roles do fire, hurricanes, or other climate-related disturbances play in shaping this landscape?

☐ **Describe the role rocks and soil play in the ecosystem.**

- How does life change the rocks and soil at the site?
- How is life dependent upon the rocks and soil at the site?
- Does the rock record include evidence of ancient disturbances? If yes, describe.
- See also the geoscience questions.

☐ **Describe the types and arrangements of plants and animals and what they indicate about present and past environments.**

- Why do living things in the environment look the way they do?
- What life forms were the earliest to arrive?
- Describe how different life forms are distributed throughout the field site.
- What is the impact of invasive species and other disturbances?
- See also the **Describe how life shapes the land** section.

Plants

- How have plants shaped the landscape?
- How has the landscape affected the plants?

Animals

- How do animals contribute to plant distribution?
- How has the landscape affected the animals?

Other biota

☐ **What effects have humans had on the landscape?**

- What resources do humans use from here?
- How have humans changed the landscape?
- On what scale?

Closing Thoughts

This chapter was written to help get you started in the creation of VFEs and, in a broader sense, to help you learn more about fieldwork. But how do you know when to stop? It may be more productive to think of VFEs or activities involving actual fieldwork as undertakings that are becoming ready for use rather than as finished products. Here is a nice quote from Wendell Berry's essay "Faustian Economics" that relates to this concept:

> *It is the artists, not the scientists, who have dealt unremittingly with the problem of limits. A painting, however large, must finally be bounded by a frame or a wall. A composer or playwright must reckon, at a minimum, with the capacity of an audience to sit still and pay attention. A story, once begun, must end somewhere within the limits of the writer's and the reader's memory. And of course the arts characteristically impose limits that are artificial: the five acts of a play, or the fourteen lines of a sonnet. Within these limits artists achieve elaborations of pattern, of sustaining relationships of parts with one another and with the whole, that may be astonishingly complex. And probably most of us can name a painting, a piece of music, a poem or play or story that still grows in meaning and remains fresh after many years of familiarity.*

Resources

Field Geology Teaching Practices

Extraordinary Science Field Trips, Summer 2013, *National Science Teachers Association Reports*, 25(1): 1–2, http://www.nsta.org/docs/NSTAReports201307.pdf.

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My Geologic Address: Locating Oneself in Geologic Time and Process, by K. Ault, SERC InTeGrate workshop “Teaching the Methods of Geoscience” activities, http://serc.carleton.edu/integrate/workshops/methods2012/activities/ault.html.

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Shulman, L. S. 2005. Signature pedagogies in the professions. *Daedalus*, 134(3): 52–59.

Teaching in the Field, National Association of Geoscience Teachers, http://nagt.org/nagt/teaching_resources/field/index.html. (Set of resources for teaching field geology.)

Whitmeyer, S. J., E. J. Pyle, & D. W. Mogk, eds. 2009. Field geology education: historical perspectives and modern approaches. *Geological Society of America Special Papers* 461, http://specialpapers.gsapubs.org/content/461.toc. (29 articles focused on undergraduate education.)

Guides to Fieldwork

(Mostly focused on post-secondary education, but useful as references.)

Coe, A., T. Argles, D. Rothery, & R. Spicer. 2010. *Geological Field Techniques*. Wiley-Blackwell, Chichester, UK, 336 pp. (This is a current standard.)

Compton, R. R. 1962. *Manual of Field Geology*. John Wiley & Sons, New York, 378 pp. (An old classic.)

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How to Read a Geologic Map, Wisconsin Geological and Natural History Survey, http://wgnhs.uwex.edu/wisconsin-geology/bedrock-geology/read-geologic map/.

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The **Teacher-Friendly** Guide™

to the Earth Science of the Southeastern US

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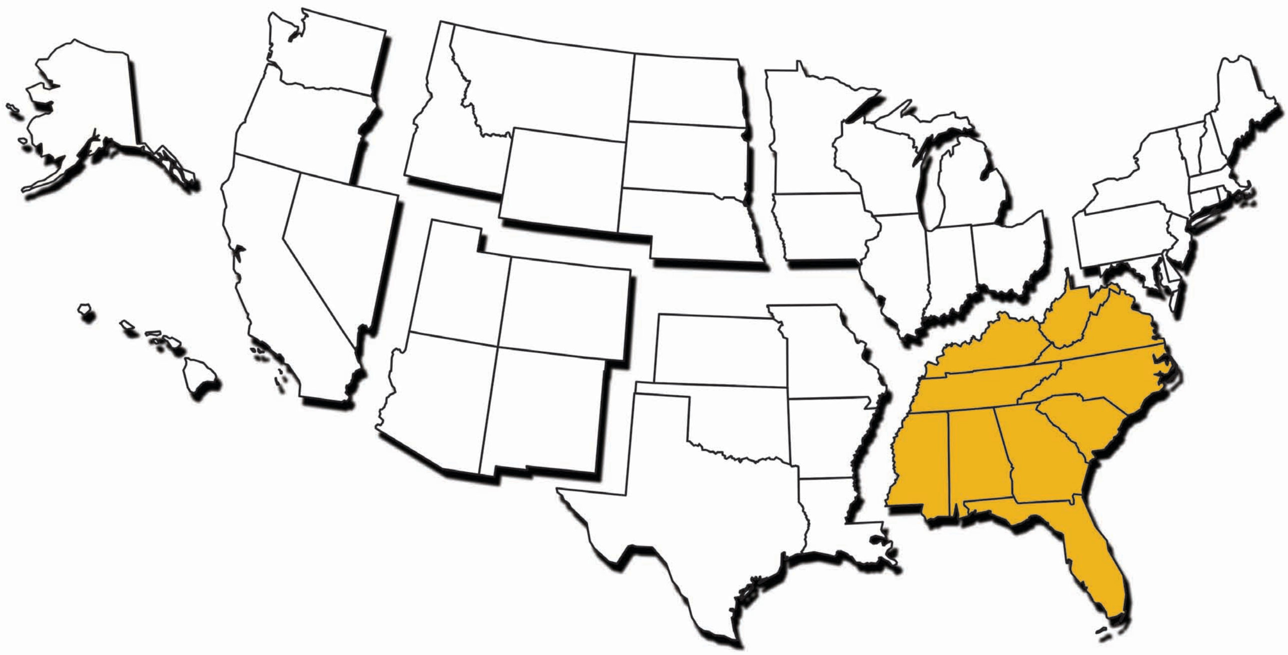

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