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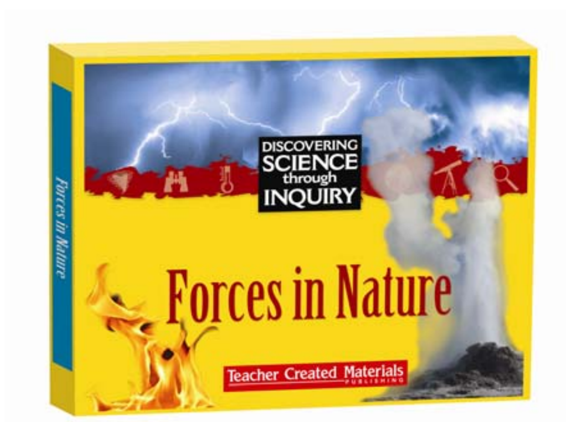
Research-Based Curriculum

Discovering Science through Inquiry

Complete Supplemental Program

Based on Respected Research & Literature



Research-Based Curriculum

Discovering Science through Inquiry

Introduction

Science has always been a cornerstone of America's education system. Renewed calls for more science instruction in today's schools have arisen since the implementation of NCLB with its intensive focus on reading and math achievement. Many educators lament the limited time they have to teach science given the constraints of federal policy. However, the benefits of effective science instruction are obvious. Education, business, and political leaders have called for more science instruction in an effort to boost America's economy and ensure continued technological innovation. In 2000, the Glenn Commission, led by Senator John Glenn, called for more effective science and math instruction in order for the United States to remain a global leader. In the Commission's report, Senator Glenn stated, "We as a nation must take immediate action to improve the quality of math and science teaching in every classroom in this country. If we delay, we put at risk our continued economic growth and future scientific discovery" (U.S. Department of Education, 2000).

Such calls for improved science instruction revealed a need for educators to have the curriculum resources necessary to effectively teach science. ***Discovering Science through Inquiry*** was created to provide research-based lessons for teachers. The program is based on current research for science inquiry methodology and instructional practices for meeting the needs of diverse learners. The materials are designed to develop students' scientific literacy skills, while also motivating students through engaging content.

The Need for Effective Science Instruction

International Achievement Comparisons

Many points in American history have declared the need for students to improve their performance in science. The 1960s brought on the space race, which led to increased focus on math and science instruction in America's schools. Government reports of the 1980s such as *A Nation at Risk* (United States, 1983) lamented American schools as failing their students. These reports highlighted the failure of American students to score above their Japanese and Russian counterparts. In the 1990s the Third International Math and Science Study (TIMSS) results showed American students performing below most industrialized nations, and even some unindustrialized ones (Martin, et. al, 2000). These results shocked American educators into focusing more on science and math instruction. Today, Americans continue to score below other nations on exams such as TIMMS and the Program for International Student Assessment (PISA) (Organization for Economic Cooperation and Development, 2006). These results continue to ignite calls for improved student learning in science.

21st Century Skills

"Having a basic knowledge of scientific principles is no longer a luxury but, in today's complex world, a necessity" (Miller, 2007). The American Association for the Advancement of Science (AAAS) began Project 2061 in order to develop and promote science literacy. The project was established with the understanding that simply offering more science content is not effective. Rather, it is more important to teach the essentials of science content more efficiently (AAAS, 1989). The authors of the paper stated that most Americans are not "science literate" and that U.S. students do not rank well in comparison to other nations in science and mathematics (AAAS, 1989). Shortly thereafter, the Association developed benchmarks for science literacy that have been used in the development of state standards. As Americans become more knowledgeable about the basics of science content, this can lead to a more sophisticated work force, better consumers, and wiser influences on public policy as it relates to scientific issues. (Miller, 2007) Clearly, there is a need for students to be educated in science concepts.

Diverse Learners

Diversity in America's public schools is a fact. This diversity spans over many languages and cultures. "Each year, the United States becomes more ethnically and linguistically diverse, with more than 90 percent of recent immigrants coming from non-English speaking countries" (Echevarria, Vogt, and Short, 2004). In U.S. classrooms, there are over three million students who are English Language Learners (NCLB, 2001). Nearly every major city in every state in the country has multilingual, multicultural student populations (Calderon, 1997). One researcher predicted in 1992 that by the year 2056, most U.S citizens would be able to trace part of their heritage to Africa, Asia, the Hispanic countries, and the Pacific Islands ─ to places that were not "white Europe" (Wittmer, 1992). Many other researchers have continued to make similar predictions about the growing demographic changes in U.S. schools.

Beyond even these differences, students also vary in other areas: learning styles, readiness levels, interests, family traditions, socioeconomic status, years of formal schooling, background experiences, and special needs. "The diverse student community can be conceptualized as a wonderful and exciting element of the world we live in and not as a hindrance to the educational process" (Sanchez, 1995). The answer to the diverse nature of today's schools *cannot* be met with simple inclusion of multicultural days and the teaching of the same cultural-relevancy lessons over and over again. "A total curriculum transformation needs to take place where the critical issues of diversity and multiculturalism are integrated into all aspects of students' academic achievement, social skills development and relationship with the community at large" (Sanchez, 1995). Thus, instruction in schools today needs to support the needs of these diverse learners. While science concepts are internationally held, the teaching methods used must meet the needs of English language learners and students with varying levels of readiness and learning styles.

Teacher Support

Teachers today are responsible for ensuring students not only understand content knowledge, but also comprehend content through difficult texts. The more recent emphasis on content-area vocabulary and reading skills requires teachers to use new strategies in science instruction. Teachers also have limited time and resources for planning and implementing this instruction. Moreover, the diverse student body entering schools today need a variety of instructional methods. Therefore, teachers need science curricula that will help them easily implement effective science instruction that meets the needs of diverse learners.

In the past, local constituents often influenced schools in making instructional decisions. Today, however, political pressure comes from the federal level, and teachers are held accountable for meeting national benchmarks for instruction (Elmore, 1997). These changing pressures place new demands on teachers in the science classroom. ***Discovering Science through Inquiry*** provides the support teachers need to meet these challenges by including comprehensive lessons that meet national and state standards.

Inquiry Science

Inquiry-Based Teaching

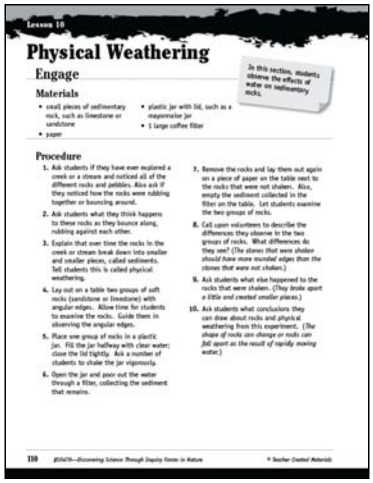
Research on science instruction since the 1980s has supported inquiry-based teaching methods. "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (National Research Council, 1996). In its official position statement on inquiry-based learning in science, the National Science Teachers Association (NSTA) encourages every teacher to make inquiry science a part of the daily curriculum at every grade level, noting that it is important to help younger learners become problem-solving learners. NSTA defines scientific inquiry as

> "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."

Benefits of Inquiry for Students

According to NSTA, students learn science best when: they are involved in firsthand exploration and investigation and inquiry/process skills are nurtured; instruction builds directly on the student's conceptual framework; content is organized on the basis of broad conceptual themes common to all science disciplines; and mathematics and communication skills are an integral part of science instruction. This position is highlighted in the National Science Education Standards (National Research Council, 1996), which view inquiry as "central to science learning." As the standards explain, "when engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations."

Despite widespread agreement on the importance of inquiry-based learning, some teachers are still hesitant to adopt this pedagogical approach in their science classrooms for a variety of reasons. Some feel it is only appropriate for advanced students; others feel inadequately prepared for this type of instruction; still others are concerned about "managing" an inquiry-based classroom, in which some would say that students may be disruptive, pay less attention, socialize, or simply not participate. Yet, research proves false regarding all of these concerns. ***Discovering Science through Inquiry*** includes easy-to-use lessons with strategies for managing inquiry instruction in the classrooms.



Lesson 10

Physical Weathering

Engage

In this section, students observe the effects of water on sedimentary rocks.

Materials

- small pieces of sedimentary rock, such as limestone or sandstone
- paper
- plastic jar with lid, such as a mayonnaise jar
- 1 large coffee filter

Procedure

1. Ask students if they have ever explored a creek or a stream and noticed all of the different rocks and pebbles. Also ask if they noticed how the rocks were rubbing together or bouncing around.
2. Ask students what they think happens to these rocks as they bounce along, rubbing against each other.
3. Explain that over time the rocks in the creek or stream break down into smaller and smaller pieces, called sediments. Tell students this is called physical weathering.
4. Lay out on a table two groups of soft rocks (sandstone or limestone) with angular edges. Allow time for students to examine the rocks. Guide them in observing the angular edges.
5. Place one group of rocks in a plastic jar. Fill the jar halfway with clear water; close the lid tightly. Ask a number of students to shake the jar vigorously.
6. Open the jar and pour out the water through a filter, collecting the sediment that remains.
7. Remove the rocks and lay them out again on a piece of paper on the table next to the rocks that were not shaken. Also, empty the sediment collected in the filter on the table. Let students examine the two groups of rocks.
8. Call upon volunteers to describe the differences they observe in the two groups of rocks. What differences do they see? *(The stones that were shaken should have more rounded edges than the stones that were not shaken.)*
9. Ask students what else happened to the rocks that were shaken. *(They broke apart a little and created smaller pieces.)*
10. Ask students what conclusions they can draw about rocks and physical weathering from this experiment. *(The shape of rocks can change or rocks can fall apart as the result of rapidly moving water.)*

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Lesson 10

Physical Weathering

Explain

In this section, students learn about the types of physical weathering and the factors that influence it.

Materials

- Inquiry Handbook
  Physical Weathering Background Information (page 78)
  Physical Weathering Map (page 79)
  Physical Weathering Vocabulary (page 80)

Procedure

1. Have students reflect on the demonstration and experiment from earlier in the lesson. Begin a discussion about physical weathering by asking students what they think might increase the rate of physical weathering of rock and minerals. Create a chart titled *Weathering Factors* on the board or overhead and write their answers or ideas.
2. Distribute copies of *Physical Weathering Background Information* and allow time for students to complete the reading. Tell students that as they are reading they should look for some of the factors that influence physical weathering.
3. Begin a discussion about the reading by reviewing with students some examples of physical weathering. *(frost wedging, root wedging, exfoliation, abrasion)*
4. Ask students what three main things (factors) influence how fast physical weathering takes place. *(climate, surface area of the rock, and type of rock)* Write those factors on the board.
5. Compare the ideas about the rate of physical weathering that students had before and after reading. Discuss, as a class, whether their ideas were correct. Have students identify what they learned about weathering factors that they did not know before.
6. Distribute copies of *Physical Weathering Map* to students. Tell them that this activity will help them organize what they know about physical weathering. Allow time for students to complete the activity in pairs or small groups.
7. Distribute copies of *Physical Weathering Vocabulary* to students. Allow them to use their reading passage as a reference when completing the activity sheet. As time permits, review the vocabulary words with the class.
8. To conclude this section of the lesson, pose the following scenario to students: The principal wants you to help decide what type of rock should be used for the new statue that is going up in the front of the school. What type of rock will you recommend to the principal and why? *(Students should recommend quartz because it takes the longest to weather.)*

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Transitioning to Inquiry-Based Instruction

Inquiry-based science lessons can take one of three approaches or range of practices: structured inquiry, guided inquiry, and open inquiry (Colburn, 2000). Teachers can incorporate these approaches based on the needs of the students or the objectives of the lesson. In some lessons, it is important for students to have a more structured or guided activity, while other lessons may be more suited for "free-ranging explorations of unexplained phenomena" (Huziak- Clark, 2003). ***Discovering Science through Inquiry*** provides lessons at varying levels of structure from open-ended inquiry activities to more structured inquiry. This gives teachers the opportunity to scaffold the development of students' science process skills.

These stages of inquiry are not independent of each other; rather they exist along a continuum. Hence, teachers do not need to transition to open inquiry-based instruction all at once. "Both students and teachers alike need time to gradually make a transition from the more classical confirmation-type activities and lectures to open-ended activities characteristic of inquiry-based instruction" (Colburn, 2000).

An inquiry-based science classroom offers both teachers and students a wonderful opportunity to explore science in an exciting way. While there is a learning curve in the adoption of this approach both for teachers and for students, research confirms that inquiry-based methods of teaching not only improve student achievement in science (across all ability groups), but also increase student interest and excitement about science (Walker, 2007).

A Model for Inquiry Teaching

Engage, Explore, Explain, Elaborate, and Evaluate

One method for structuring an inquiry-based instructional approach is based on a model developed by Biological Science Curriculum Study (BSCS). This model employs the 5Es—engage, explore, explain, elaborate, and evaluate—and is based on a constructivist philosophy of learning. In this philosophy of learning, students build or construct their own understanding of new ideas based on what they already know. Each E represents part of a sequential instructional process or learning cycle designed to help students construct their own learning experiences and ultimate understanding of the topic or concept. The general goals and activities at each stage in the 5E model include:

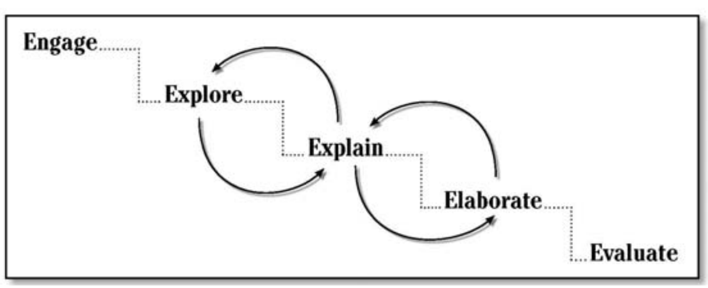
- **Engage:** At this stage, teachers introduce a topic or concept with an intriguing, fascinating, or challenging question or demonstration designed to capture students' interest, curiosity, and attention. At this stage, teachers do not seek a "right answer;" rather they prompt students to talk about what they already know about the topic (or think they may know) and discuss what else students would like to know.

- **Explore:** During exploration, students conduct various hands-on or problem solving activities and experiments designed to help them explore the topic and make connections to related concepts, often within groups or teams. During this stage, students share common experiences while the teacher acts as a facilitator, providing materials as needed and guiding the students' focus.

- **Explain:** At this stage, teachers help students observe patterns, analyze results, and/or draw conclusions based on their activities and investigations. Teachers also define relevant vocabulary.

- **Elaborate:** In this stage, students build on the concepts or ideas they have learned and make connections to other related concepts and new situations.

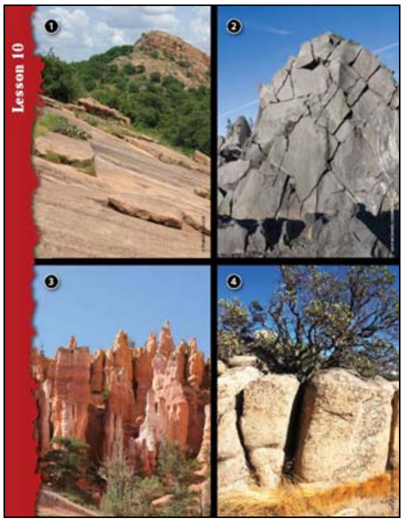
- **Evaluate:** In the final stage, teachers evaluate, or assess, students' understanding of the topic studied. This evaluation can be formal or informal but should demonstrate a clear understanding of what students have learned throughout the course of the lesson.



The 5'Es of science inquiry model are fluid allowing for assessment and re-teaching of concepts.

Prerequisites for Inquiry Learning

Research supports the use of inquiry teaching in the science classroom, but many teachers find it difficult to do. Fisher, Grant & Frey (2009) found that students need background knowledge before they can effectively learn science content using inquiry methods. They note that building background knowledge is one of the most important prerequisites for student learning in science. ***Discovering Science through Inquiry*** provides essential background knowledge for each lesson in the student inquiry handbook and on full color cards. Furthermore, this information is often represented both visually and in text form.



Lesson 10

Physical Weathering

All About Physical Weathering

Have you ever looked carefully at a very old stone monument? Were the words on the monument hard to read? Chances are they were. That is because of a process called *weathering*.

There are two kinds of weathering. One is called *chemical weathering*. Chemical weathering changes the chemical makeup of a rock.

The other weathering process is called *physical weathering*. Physical weathering breaks down rocks into smaller pieces. It is the first step in erosion.

How fast does weathering break down rocks? That depends on a number of things. The surface area of the rock is one. Imagine a perfectly solid rock. Now imagine that same rock with a crack in it. Which rock will weather more quickly? The answer is the rock with the crack. That's because the surface area of the rock with the crack is greater. There is a bigger area for weathering to take place.

Climate is another thing that influences how fast rocks weather. A cold, moist area is likely to cause more physical weathering. Water gets into cracks in a rock. It freezes. Later, it thaws. Over time, the freeze-thaw action breaks the rock apart.

The type of rock is something else that influences weathering. Different rocks are made up of different minerals. Those minerals will weather at different rates. Sandstone, for example, is made up of quartz. It is very strong. It does not weather easily.

Limestone, on the other hand, is made up of calcite. That is a mineral that is soluble. In a dry desert climate, limestone will not weather at all. But in a wet climate it will eventually dissolve completely. (That is why there is a lot of weathering of limestone in tropical areas.)

Most monuments are made of granite. Granite contains quartz. It is a strong stone. But even granite, over many years, will show signs of weathering.

Take a look around your neighborhood. Look at old stone monuments or gravestones. Maybe you will see some signs of weathering.

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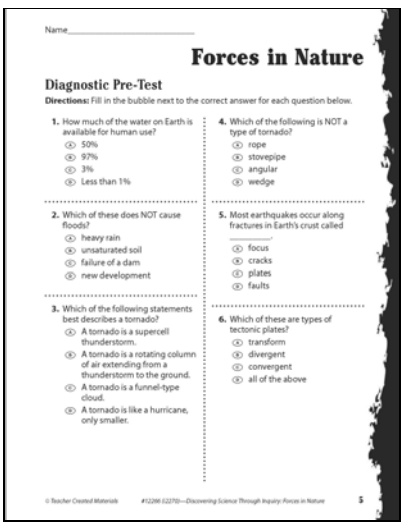
Fisher, Grant & Frey (2009, p. 184) stress the importance of building background knowledge with inquiry science, saying, "To neglect this foundation is to reduce science to a collection of facts to be memorized, rather than to present science as a range of processes that validate and extend real-world understandings."

Assessment

Assessment is an important part of instruction in any content area. It is an ongoing, long-term process that can be conducted formally or informally. Although written tests are part of assessments, informal observations, student work, listening to groups communicate with one another, and science experiments can also be used to monitor students' progress, identify students' misconceptions, and identify their level of mastery for skills and concepts.

In order for students to achieve a high level of understanding of the scientific concepts presented, it is important that teachers provide students with the appropriate instruction, materials and support. Therefore, it is the responsibility of the teacher to conduct both formal and informal assessments to monitor students' understanding and use that information to guide future instruction. The results of the assessments can help teachers determine whether re-teaching is necessary for some or all students, and whether or not it is time to progress to the next lesson. The 5 E instructional model fluidly allows for assessment and re-teaching opportunities. Each lesson begins with an engaging activity that grabs the students' attention. The Explore section of the lesson involves students' investigation of the concept either independently or with some teacher guidance. Once exploration of the concept is complete, the teacher explains the concept and discusses the experiment with the students. Here, the teacher can informally assess whether students are beginning to understand that concept. If they are not, students should spend more time exploring the concept. If students understand the concept, the teacher should move to the Elaborate section of the lesson. Here, students make connections to other scientific concepts and extend what they have learned. Finally, when students are successfully making connections and extending the scientific concept, they can be formally evaluated on their knowledge.

Within the ***Discovering Science through Inquiry*** program, there is a diagnostic test for the whole program, as well as a less-extensive formal assessment at the end of each lesson. The diagnostic test can be used to assess students' understanding of the concepts addressed in this resource. The test can be given as a pre-test before instruction from the unit begins.



Name________________________

Forces in Nature

Diagnostic Pre-Test

Directions: Fill in the bubble next to the correct answer for each question below.

1. How much of the water on Earth is available for human use?
   - Ⓐ 50%
   - Ⓑ 97%
   - Ⓒ 3%
   - Ⓓ Less than 1%
2. Which of these does NOT cause floods?
   - Ⓐ heavy rain
   - Ⓑ unsaturated soil
   - Ⓒ failure of a dam
   - Ⓓ new development
3. Which of the following statements best describes a tornado?
   - Ⓐ A tornado is a supercell thunderstorm.
   - Ⓑ A tornado is a rotating column of air extending from a thunderstorm to the ground.
   - Ⓒ A tornado is a funnel-type cloud.
   - Ⓓ A tornado is like a hurricane, only smaller.
4. Which of the following is NOT a type of tornado?
   - Ⓐ rope
   - Ⓑ stovepipe
   - Ⓒ angular
   - Ⓓ wedge
5. Most earthquakes occur along fractures in Earth's crust called ________.
   - Ⓐ focus
   - Ⓑ cracks
   - Ⓒ plates
   - Ⓓ faults
6. Which of these are types of tectonic plates?
   - Ⓐ transform
   - Ⓑ divergent
   - Ⓒ convergent
   - Ⓓ all of the above

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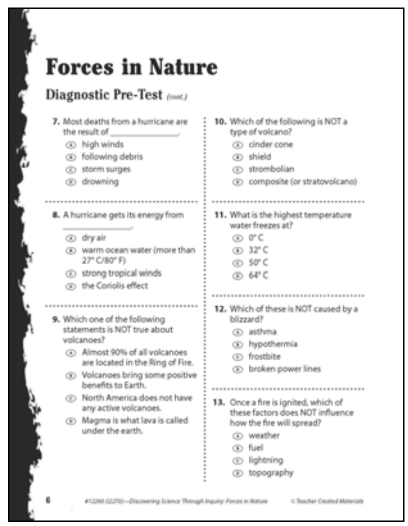

Forces in Nature

Diagnostic Pre-Test *(cont.)*

7. Most deaths from a hurricane are the result of ______________.
   - Ⓐ high winds
   - Ⓑ following debris
   - Ⓒ storm surges
   - Ⓓ drowning
8. A hurricane gets its energy from ____________.
   - Ⓐ dry air
   - Ⓑ warm ocean water (more than 27° C/80° F)
   - Ⓒ strong tropical winds
   - Ⓓ the Coriolis effect
9. Which one of the following statements is NOT true about volcanoes?
   - Ⓐ Almost 90% of all volcanoes are located in the Ring of Fire.
   - Ⓑ Volcanoes bring some positive benefits to Earth.
   - Ⓒ North America does not have any active volcanoes.
   - Ⓓ Magma is what lava is called under the earth.
10. Which of the following is NOT a type of volcano?
    - Ⓐ cinder cone
    - Ⓑ shield
    - Ⓒ strombolian
    - Ⓓ composite (or stratovolcano)
11. What is the highest temperature water freezes at?
    - Ⓐ 0° C
    - Ⓑ 32° C
    - Ⓒ 50° C
    - Ⓓ 64° C
12. Which of these is NOT caused by a blizzard?
    - Ⓐ asthma
    - Ⓑ hypothermia
    - Ⓒ frostbite
    - Ⓓ broken power lines
13. Once a fire is ignited, which of these factors does NOT influence how the fire will spread?
    - Ⓐ weather
    - Ⓑ fuel
    - Ⓒ lightning
    - Ⓓ topography

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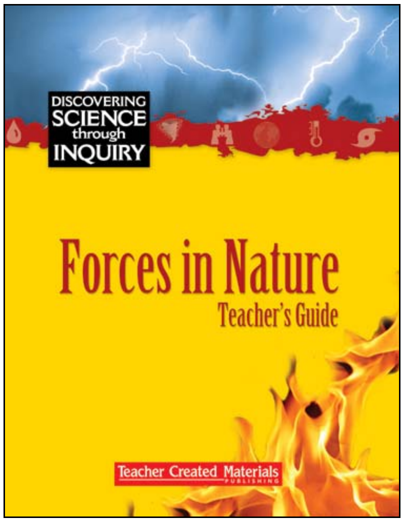
Diagnostic assessments ensure students are taught at the most appropriate level.

Support for Teachers

Teachers also need support when implementing inquiry science. Jones and Eick (2007) note that teachers need extensive support from the bottom up in order to effectively teach science using inquiry methods. They suggest that professional development schools can support pre-service teachers by providing extensive coaching during lessons. But what support is provided for in-service teachers attempting to implement inquiry science methods? Jones and Eick found that teachers need support in scientific content knowledge, as well as in teaching processes. ***Discovering Science through Inquiry*** includes clear, steps for each lesson in the teacher’s guide. Having an easy-to-follow teacher’s guide provides in-service teachers with essential support in leading the processes in an inquiry lesson. This is especially important when teaching inquiry science, because the methods often go against the traditional didactic pedagogy learned by most in-service teachers. Additionally, the teacher’s guide includes the subject-area information that teachers need to confidently teach the science content found in the lessons.



Lesson 10

Physical Weathering

Background Information for the Teacher

There is a difference between weathering and erosion. Weathering is the process by which rocks and minerals are gradually broken down. Erosion is the breaking down of rocks that are removed by weathering agents such water, ice, or wind.

Weathering plays an important role in the shape of the landscape of the world. It is divided into two different classifications: physical (or mechanical) weathering and chemical weathering. This lesson focuses on physical weathering.

Physical weathering (or physical disintegration) is the breaking down of rocks into smaller pieces through direct contact with atmospheric conditions, such as heat, water, and ice. However, it does not change the chemical composition of rock.

One way to understand the difference between physical weathering versus chemical weathering is to imagine two pieces of paper that are the same size. The first piece of paper is torn into tiny pieces. Then the second one is burned.

Tearing up the piece of paper is an example of physical disintegration. Even though the paper is shredded into tiny pieces, the physical properties of the paper have not changed.

By contrast, burning the second piece of paper is an example of chemical decomposition. That is because burning the paper leaves a new composition of ashes.

Primary Forms of Physical Weathering

There are four different forms of physical weathering:

frost wedging: This occurs when water gets into fractures and tiny cracks of rocks. When the water freezes, its volume increases by almost 10 percent. This causes outward pressure. The continual freeze-thaw action eventually causes the rock to break apart.

exfoliation: This is a process in which rocks break apart in layers parallel to the earth's surface.

abrasion: This occurs when wind blows sand and other small particles across the surface of rock, wearing away the surface via friction.

plant (root) wedging: This is similar to frost wedging. When plant roots push into a rock or under a rock, they break rocks apart as they grow.

Factors That Influence Physical Weathering

There are three main factors that influence how fast a rock disintegrates as the result of physical weathering:

- climate
- exposed surface area of the rock
- type of rock

Once rock is broken down into smaller pieces—either as the result of physical weathering or chemical weathering—the process of erosion can begin.

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Background information is included in the teacher’s guide for each lesson. This strengthens teachers’ content knowledge to better lead science inquiry.

Conclusion

Science is a core subject area that many feel has been neglected in recent years. Educators need new methods and resources for teaching science given the constraints they feel in today’s educational climate. Research has identified the constructivist model of inquiry teaching as the most effective method for student learning. Lessons in ***Discovering Science through Inquiry*** provide five levels of inquiry for students. Materials in the program also include engaging content and texts written at a variety of reading levels to support diverse learners. Further, ongoing assessment is an essential component for data-driven instruction. Both formative and summative assessments are included in the program to guide teachers’ pedagogy. Overall, ***Discovering Science through Inquiry*** provides teachers with a comprehensive program to assess and meet the needs of all students for key science content topics.

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