Argument-Driven Inquiry in Fourth-Grade Science

Three-Dimensional Investigations

Victor Sampson and Ashley Murphy

NSTA press
National Science Teachers Association

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Preface

There are a number of potential reasons for teaching children about science in elementary school. Some people, for example, think it is important to focus on science in the early grades to get students interested in science early so that more people will choose to go into a science or science-related career. Some people think that it is important to teach science in the early grades because children ask so many questions about how the world works, and the information included as part of the science curriculum is a great way to answer many of their questions. Others think it is important to focus on science in elementary school because children need a strong foundation in the basics so they will be prepared for what they will be expected to know or do in middle or high school. Few people, however, emphasize the importance of teaching science because it is useful for everyday life (Bybee and Pruitt 2017).

Science is useful because it, along with engineering, mathematics, and the technologies that are made possible by these three fields, affects almost every aspect of modern life in one way or another. For example, people need to understand science to be able to think meaningfully about different policy issues that affect their communities or to make informed decisions about what food to eat, what medicine to take, or what products to use. People can use their understanding of science to help evaluate the acceptability of different ideas or to convince others about the best course of action to take when faced with a wide range of options. In addition, understanding how science works and all the new scientific findings that are reported each year in the media can be interesting, relevant, and meaningful on a personal level and can open doors to exciting new professional opportunities. The more a person understands science, which includes the theories, models, and laws that scientists have developed over time to explain how and why things happen and how these ideas are developed and refined based on evidence, the easier it is for that person to have a productive and fulfilling life in our technology-based and information-rich society. Science is therefore useful to everyone, not just future scientists.

A Framework for K–12 Science Education (NRC 2012; henceforth referred to as the *Framework*) is based on the idea that all citizens should be able to use scientific ideas to inform both individual choices and collective choices as members of a modern democratic society. It also acknowledges the fact that professional growth and economic opportunity are increasingly tied to the ability to use scientific ideas, processes, and ways of thinking. From the perspective of the *Framework*, it is important for children to learn science because it can help them figure things out or solve problems. It is not enough to remember some facts and terms; people need to be able to use what they have learned while in school. This goal for science education represents a major shift in what should be valued inside the classroom.

The *Framework* asks all of us, as teachers, to reconsider what we teach in grades K–5 and how we teach it, given this goal for science education. It calls for all students, over multiple years of school, to learn how to use disciplinary core ideas (DCIs), crosscutting concepts (CCs), and scientific and engineering practices (SEPs) to figure things out or solve problems. The DCIs are key organizing principles that have broad explanatory power within a discipline. Scientists use these ideas to explain the natural world. The CCs are ideas that are used across disciplines. These concepts provide a framework or a lens that people can use to explore natural phenomena; thus, these concepts often influence what people focus on or pay attention to when they attempt to understand how something works or why something happens. The SEPs are the different activities that scientists engage in as they attempt to generate new concepts, models, theories, or laws that are both valid and reliable. All three of these dimensions of science are important. Students not only need to know about the DCIs, CCs, and SEPs but also must be able to use all three dimensions at the same time to figure things out or to solve problems. These important DCIs, CCs, and SEPs are summarized in Table P-1.

When we give students an opportunity to learn how to use DCIs, CCs, and SEPs to make sense of the world around them, we also provide an authentic context for students to develop fundamental literacy and mathematic skills. Students are able to develop literacy and mathematics skills in this type of context because doing science requires people to obtain, evaluate, and communicate information. Students, for example, must read and talk to others to learn what others have done and what they are thinking. Students must write and speak to share their ideas about what they have learned or what they still need to learn. Students can use mathematics to make measurements; to discover trends, patterns, or relationships in their observations; and to make predictions about what will happen in the future. When we give students opportunities to do science, we also give students a reason to read, write, speak, and listen, and we create a need for them to use mathematics.

To help students learn how to use DCIs, CCs, and SEPs to figure things out or solve problems while providing a context for students to develop fundamental literacy and mathematics skills, elementary teachers will need to use new instructional approaches. These instructional approaches must give students an opportunity to actually do science. To help teachers in elementary schools make this instructional shift, we have developed a tool called argument-driven inquiry (ADI). ADI is an innovative approach to instruction that gives students an opportunity to use DCIs, CCs, and SEPs to construct and critique claims about how things work or why things happen. As part of this process, students must talk, listen, read, and write to obtain, evaluate, and communicate information. ADI, as a result, creates a rich learning environment for children that enables them to learn science, language, and mathematics at the same time.

TABLE P-1

The three dimensions of *A Framework for K–12 Science Education*

Science and engineering practices (SEPs)	Crosscutting concepts (CCs)
• SEP 1: Asking Questions and Defining Problems • SEP 2: Developing and Using Models • SEP 3: Planning and Carrying Out Investigations • SEP 4: Analyzing and Interpreting Data • SEP 5: Using Mathematics and Computational Thinking • SEP 6: Constructing Explanations and Designing Solutions • SEP 7: Engaging in Argument From Evidence • SEP 8: Obtaining, Evaluating, and Communicating Information	• CC 1: Patterns • CC 2: Cause and Effect: Mechanism and Explanation • CC 3: Scale, Proportion, and Quantity • CC 4: Systems and System Models • CC 5: Energy and Matter: Flows, Cycles, and Conservation • CC 6: Structure and Function • CC 7: Stability and Change

Disciplinary core ideas		
Earth and Space Sciences (ESS)	**Life Sciences (LS)**	**Physical Sciences (PS)**
• ESS1: Earth's Place in the Universe • ESS2: Earth's Systems • ESS3: Earth and Human Activity	• LS1: From Molecules to Organisms: Structures and Processes • LS2: Ecosystems: Interactions, Energy, and Dynamics • LS3: Heredity: Inheritance and Variation of Traits • LS4: Biological Evolution: Unity and Diversity	• PS1: Matter and Its Interactions • PS2: Motion and Stability: Forces and Interactions • PS3: Energy • PS4: Waves and Their Applications in Technologies for Information Transfer

Source: Adapted from NRC 2012.

This book describes how ADI works and why it is important, and it provides 15 investigations that can be used in the classroom to help students reach the performance expectations found in the *Next Generation Science Standards* (NGSS Lead States 2013) for fourth grade.[1] The 15 investigations described in this book will also enable students to develop the disciplinary-based literacy skills outlined in the *Common*

1 See *Argument-Driven Inquiry in Third-Grade Science: Three-Dimensional Investigations* (Sampson and Murphy 2019) and *Argument-Driven Inquiry in Fifth-Grade Science: Three-Dimensional Investigations* (Sampson and Murphy, forthcoming) for additional investigations for students in elementary school.

Core State Standards for English language arts (NGAC and CCSSO 2010) because ADI gives students an opportunity to make presentations to their peers; respond to audience questions and critiques; and then write, evaluate, and revise reports as part of each investigation. In addition, these investigations will help students learn many of the mathematical ideas and practices outlined in the *Common Core State Standards* for mathematics (NGAC and CCSSO 2010) because ADI gives students an opportunity to use mathematics to collect, analyze, and interpret data. Finally, and perhaps most important, ADI can help emerging bilingual students meet the *English Language Proficiency (ELP) Standards* (CCSSO 2014) because it provides a language-rich context where children can use receptive and productive language to communicate and to negotiate meaning with others. Teachers can therefore use these investigations to align how and what they teach with current recommendations for improving science education.

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Introduction

A Vision for Science Education in Elementary School

The current aim of science education in the United States is for *all* students to become proficient in science by the time they finish high school. *Science proficiency*, as defined by Duschl, Schweingruber, and Shouse (2007), consists of four interrelated aspects. First, it requires an individual to know important scientific explanations about the natural world, to be able to use these explanations to solve problems, and to be able to understand new explanations when they are introduced to the individual. Second, it requires an individual to be able to generate and evaluate scientific explanations and scientific arguments. Third, it requires an individual to understand the nature of scientific knowledge and how scientific knowledge develops over time. Finally, and perhaps most important, an individual who is proficient in science should be able to participate in scientific practices (such as planning and carrying out investigations, analyzing and interpreting data, and arguing from evidence) and communicate in a manner that is consistent with the norms of the scientific community. These four aspects of science proficiency include the knowledge and skills that all people need to have in order to be able to pursue a degree in science, be prepared for a science-related career, and participate in a democracy as an informed citizen.

This view of science proficiency serves as the foundation for *A Framework for K–12 Science Education* (the *Framework*, NRC 2012). The *Framework* calls for all students to learn how to use disciplinary core ideas (DCIs), crosscutting concepts (CCs), and scientific and engineering practices (SEPs) to figure things out or solve problems as a way to help them develop the four aspects of science proficiency. The *Framework* was used to guide the development of the *Next Generation Science Standards* (*NGSS;* NGSS Lead States 2013). The goal of the *NGSS*, and other sets of academic standards that are based on the *Framework*, is to describe what *all* students should be able to do at each grade level or at the end of each course as they progress toward the ultimate goal of science proficiency.

The DCIs found in the *Framework* and the *NGSS* are scientific theories, laws, or principles that are central to understanding a variety of natural phenomena. An example of a DCI in Earth and Space Sciences is that the solar system consists of the Sun and a collection of objects that are held in orbit around the Sun by its gravitational pull on them. This DCI can be used not only to help explain the motion of planets around the Sun but also to help explain why we have tides on Earth, why the appearance of the Moon changes over time in a predictable pattern, and why we see eclipses of the Sun and the Moon.

The CCs are ideas that are important across the disciplines of science. The CCs help people think about what to focus on or pay attention to during an investigation. For example, one of the CCs from the *Framework* is Energy and Matter: Flows, Cycles, and Conservation. This CC is important in many different fields of study, including astronomy, biology, geology, meteorology, and physics. Biologists use this CC when they study how cells work, the growth and development of plants or animals, and the nature of ecosystems. Physicists use this CC when they study how things move; why things change temperature; and the behavior of circuits, magnets, and generators. It is important to highlight the centrality of the CC Energy and Matter: Flows, Cycles, and Conservation, and the other CCs, for students as we teach the subject-specific DCIs.

The SEPs describe what scientists do as they attempt to make sense of the natural world. Students engage in practices to build, deepen, and apply their knowledge of DCIs and CCs. Some of the SEPs include familiar aspects of what we typically associate with "doing" science, such as Asking Questions and Defining Problems, Planning and Carrying Out Investigations, and Analyzing and Interpreting Data. More important, however, some of the SEPs focus on activities that are related to developing and sharing new ideas, solutions to problems, or answers to questions. These SEPs include Developing and Using Models; Constructing Explanations and Designing Solutions; Engaging in Argument From Evidence; and Obtaining, Evaluating, and Communicating Information. All of these SEPs are important to learn because scientists engage in different practices, at different times, and in different orders depending on what they are studying and what they are trying to accomplish at that point in time.

Few students in elementary school have an opportunity to learn how to use DCIs, CCs, and SEPs to figure things out or to solve problems. Instead, most students are introduced to facts, concepts, and vocabulary without a real reason to know or use them. This type of focus in elementary classrooms does little to promote and support the development of science proficiency because it emphasizes "learning about" science rather than learning how to use science to "figure things out." This type of focus also reflects a view of teaching that defines *rigor* as covering more topics and *learning* as the simple acquisition of more information.

We must think about rigor in different ways before we can start teaching science in ways described by the *Framework*. Instead of using the number of different topics covered in a particular grade level as a way to measure rigor in our schools (e.g., "we made fourth grade more rigorous by adding more topics for students to learn about"), we must start to measure rigor in terms of the number of opportunities students have to use DCIs, CCs, and SEPs to make sense of different phenomena (e.g., "we made fourth grade more rigorous because students have to figure out how the energy of a moving object changes after a collision"). A rigorous class, in other words, should be viewed as one where students are expected to do science, not just learn about science. From this perspective, our goal as teachers should be to help our students learn how to use DCIs and CCs as tools to plan and carry out investigations, construct and evaluate explanations, and question how we know what we know instead of just ensuring that we “cover” all the different DCIs and CCs that are included in the standards by the end of the school year.

To better promote and support the development of science proficiency, we must also rethink what learning is and how it happens. Rather then viewing learning as an individual process where children accumulate more and more information over time, we need to view learning as a social and then an individual process that involves being exposed to new ideas and ways of doing things, trying out these new ideas and practices under the guidance of more experienced people, and then adopting the ideas and practices that are found to be useful for making sense of the world (NRC 1999, 2008, 2012). Learning, from this perspective, requires children to “do science” while in school not because it is fun or interesting (which is true for many) but because doing science gives children a reason to use the ideas and practices of science. When children are given repeated opportunities to use DCIs, CCs, and SEPs as a way to make sense of the world, they will begin to see why these DCIs, CCs, and SEPs are valuable. Over time, children will then adopt these ideas, concepts, and practices and start using them on their own. We therefore must give our students an opportunity to experience how scientists figure things out and share ideas so they can become “socialized to a greater or lesser extent into the practices of the scientific community with its particular purposes, ways of seeing, and ways of supporting its knowledge claims” (Driver et al. 1994, p. 8).

It is important to keep in mind that helping children learn how to use the DCIs, CCs, and SEPs to figure things out by giving them an opportunity to do science is not a “hands-off” approach to teaching. The process of learning to use DCIs, CCs, and SEPs to figure things out requires constant input and guidance about “what counts” from teachers who are familiar with the goals of science, the norms of science, and the ways things are done in science. Thus, learning how to use DCIs, CCs, and SEPs to figure things out or to solve problems is dependent on supportive and informative interactions with teachers. This is important because students must have a supportive and educative learning environment to try out new ideas and practices, make mistakes, and refine what they know and how they do things before they are able to adopt the ideas and practices of science as their own.

The Need for New Ways of Teaching Science in Elementary School

Science in elementary school is often taught though a combination of direct instruction and hands-on activities. A typical lesson often begins with the teacher introducing students to a new concept and related terms through direct instruction. Next, the teacher will often show the students a demonstration or give them a hands-on activity to complete to illustrate the concept. The purpose of including a demonstration or a hands-on activity in the lesson is to provide the students with a memorable experience with the concept. If the memorable experience is a hands-on activity, the teacher will often provide his or her students with a step-by-step procedure to follow and a data table to fill out to help ensure that no one in the class "gets lost" or "does the wrong thing" and everyone "gets the right results." The teacher will usually assign a set of questions for the students to answer on their own or in groups after the demonstration or the hands-on activity to make sure that everyone in the class "reaches the right conclusion." The lesson usually ends with the teacher reviewing the concept and all related terms to make sure that everyone in the class learned what they were "supposed to have learned." The teacher often accomplishes this last step of the lesson by leading a whole-class discussion, by assigning a worksheet to complete, or by having the students play an educational game.

Classroom-based research, however, suggests that this type of lesson does little to help students learn key concepts (Duschl, Schweingruber, and Shouse 2007; NRC 2008, 2012). This finding is troubling because, as noted earlier, one of the main goals of this type of lesson is to help students understand an important concept by giving them a memorable experience with it. In addition, this type of lesson does little to help students learn how to plan and carry out investigations or analyze and interpret data, because students have no voice or choice during the activity. Students are expected to simply follow a set of directions rather than having to think about what data they will collect, how they will collect it, and what they will need to do to analyze it once they have it. These types of activities can also lead to misunderstanding about the nature of scientific knowledge and how this knowledge is developed over time due to the emphasis on following procedure and getting the right results. These hand-on activities, as a result, do not reflect how science is done at all.

Over the last decade, many elementary school teachers have adopted more inquiry-based approaches to science teaching to address the many shortcomings of these typical science lessons. Inquiry-based lessons that are consistent with the definition of *inquiry* found in *Inquiry and the National Science Education Standards* (NRC 2000) share five key features:

1. Students need to answer a scientifically oriented question.
2. Students must collect data or use data collected by someone else.
3. Students formulate an answer to the question based on their analysis of the data.
4. Students connect their answer to some theory, model, or law.
5. Students communicate their answer to the question to someone else.

Teachers often use inquiry-based lessons as a way to give students a firsthand experience with a concept before introducing terms and vocabulary (NRC 2012). Inquiry-based lessons, as a result, are often described as an "activity before content" approach to teaching science (Cavanagh 2007). The focus of these "activity before content" lessons, as the name implies, is to help students understand the core ideas of science. Inquiry-based lessons also give students more opportunities to learn how to plan and carry out investigations, analyze and interpret data, and develop explanations. These lessons also give students more voice and choice so they are more consistent with how science is done.

Although classroom-based research indicates that inquiry-based lessons are effective at helping students understand core ideas and give students more voice and choice than typical science lessons, they do not do as much as they could do to help students develop all four aspects of science proficiency (Duschl, Schweingruber, and Shouse 2007; NRC 2008, 2012). For example, inquiry-based lessons are usually not designed in a way that encourages students to learn how to use DCIs, CCs, and SEPs because they are often used to help student "learn about" important concepts or principles (NRC 2012). These lessons also do not give students an opportunity to participate in the full range of SEPs because these lessons tend to be designed in a way that gives students many opportunities to learn how to ask questions, plan and carry out investigations, and analyze and interpret data but few opportunities to learn how to participate in the practices that focus on how new ideas are developed, shared, refined, and eventually validated within the scientific community. These important sense-making practices include developing and using models; constructing explanations; arguing from evidence; and obtaining, evaluating, and communicating information (NRC 2012). Inquiry-based lessons that do not focus on sense-making also do not provide a context that creates a need for students to read, write, and speak, because these lessons tend to focus on introducing students to new ideas and how to design and carry out investigations instead of how to develop, share, critique, and revise ideas. These types of inquiry-based lessons, as a result, are often not used as a way to help students develop fundamental literacy skills. To help address this problem, teachers will need to start using instructional approaches that give students more opportunities to figure things out.

This emphasis on "figuring things out" instead of "learning about things" represents a big change in the way we have been teaching science in elementary schools. To figure out how things work or why things happen in a way that is consistent with how science is actually done, students must have opportunities to use DCIs, CCs, and SEPs at the same time to make sense of the world around them (NRC 2012). This focus on students using DCIs, CCs, and SEPs at the same time during a lesson is called *three-dimensional instruction* because students have an opportunity to use all three dimensions of the *Framework* to understand how something works, to explain why something happens, or to develop a novel solution to a problem. When teachers use three-dimensional instruction inside their classrooms, they encourage students to develop or use conceptual models, develop explanations, share and critique ideas, and argue from evidence, all of which allow students to develop the knowledge and skills they need to be proficient in science. A large body of research suggests that all students benefit from three-dimensional instruction because it gives all students more voice and choice during a lesson and it makes the learning process inside the classroom more active and inclusive (NRC 2012).

We think investigations that focus on making sense of how the world works are the perfect way to integrate three-dimensional science instruction into elementary classrooms. Well-designed investigations can provide opportunities for students not only to use one or more DCIs to understand how something works, to explain why something happens, or to develop a novel solution to a problem but also to use several different CCs and SEPs during the same lesson. A teacher, for example, can give his or her students an opportunity to figure out how the energy of a moving object changes after a collision. The teacher can then encourage them to use what they know about energy (a DCI) and their understanding of Patterns and of Scale, Proportion, and Quantity (two different CCs) to plan and carry out an investigation to figure out how the speed of a rolling ball changes after it collides with objects that have more or less mass. In addition to planning and carrying out an investigation, they must also ask questions; analyze and interpret data; use mathematics; construct an explanation; argue from evidence; and obtain, evaluate, and communicate information (seven different SEPs).

Using a DCI along with multiple CCs and SEPs at the same time is important because it creates a classroom experience that parallels how science is done. This, in turn, gives all students who participate in the investigation an opportunity to deepen their understanding of what it means to do science and to develop science-related identities (Carlone, Scott, and Lowder 2014; Tan and Barton 2008, 2010). In the following section, we will describe how to promote and support the development of science proficiency through three-dimensional instruction by using an innovative instructional model called argument-driven inquiry (ADI).

Argument-Driven Inquiry as a Way to Promote Three-Dimensional Instruction While Focusing on Literacy and Mathematics

The ADI instructional model (Sampson and Gleim 2009; Sampson, Grooms, and Walker 2009, 2011) was developed as a way to change how science is taught in our schools. Rather than simply encouraging students to learn about the facts, concepts, and terms of science, ADI gives students an opportunity to use DCIs, CCs, and SEPs to figure out how things work or why things happen. ADI also encourages children to think about "how we know" in addition to "what we have figured out." The ADI instructional model includes eight stages of classroom activity. These eight stages give children an opportunity to *investigate* a phenomenon; *make sense* of that phenomenon; and *evaluate and refine* ideas, explanations, or arguments. These three aspects of doing science help students learn how to figure something out and make it possible for them to develop and refine their understanding of the DCIs, CCs, and SEPs over time.

Students will use different SEPs depending on what they are trying to accomplish during an investigation, which changes as they move through the eight stages of ADI. For example, students must learn how to ask questions to design and carry out an investigation in order to investigate a phenomenon, which is the overall goal of the first two stages of ADI. During the third stage of ADI, the students must learn how to analyze and interpret data, use mathematics, develop models, and construct explanations to accomplish the goal of making sense of the phenomenon they are studying. Students then need to ask questions; obtain, evaluate, and communicate information; and argue from evidence to accomplish the goal of evaluating and refining ideas, explanations, or arguments during the last five stages of ADI. Thus, as students move through the eight stages of ADI, they must learn how to use each of the SEPs, along with DCIs and CCs, to *investigate* a phenomenon, *make sense* of that phenomenon, and *evaluate and refine* their explanations and arguments about what they figured out. We will discuss what students do during each stage of ADI in greater detail in Chapter 1.

ADI also provides an authentic context for students to develop fundamental literacy and mathematics skills. Students are able to develop these skills during an ADI investigation because the use of DCIs, CCs, and SEPs requires people to gather, analyze, interpret, and communicate information. Students, for example, must read and talk to others to gather information and to find out how others are thinking. Students must also talk and write to share their ideas about what they are doing and what they have found out and to revise an explanation or model. Students, as a result, "are able to fine-tune their literacy skills when they engage in science investigations because so many of the sense-making tools of science are consistent with, if not identical to, those of literacy, thus allowing a setting for additional practice and refinement that can enhance future reading and writing efforts" (Pearson, Moje, and Greenleaf 2010, p. 460). Students must also use mathematics during an ADI investigation to measure what they are studying and to find patterns in their observations, uncover differences between groups, identify a trend over time, or confirm a relationship between two variables. They also use mathematics to make predictions. Teachers can therefore use ADI to help students develop important literacy and mathematics skills as they teach science. We will discuss how to promote and support the development of literacy and mathematics skills during the various stages of ADI in greater detail in Chapter 1. We will also describe ways to promote and support productive talk, reading, and writing during ADI in the Teacher Notes for each investigation.

ADI investigations also provide a rich language-learning environment for emerging bilingual students who are learning how to communicate in English. A rich language-learning environment is important because emerging bilingual students must (1) interact with people who know English well enough to provide both access to this language and help in learning it and (2) be in a social setting that will bring them in contact with these individuals so they have an opportunity to learn (Lee, Quinn, and Valdés 2013). Once these two conditions are met, people are able to learn a new language through meaningful use and interaction (Brown 2007; García 2005; García and Hamayan 2006; Kramsch 1998). ADI, and its focus on giving students opportunities to use DCIs, CCs, and SEPs to figure things out, also provides emerging bilingual students with opportunities to interact with English speakers and opportunities to do things with language inside the classroom (Lee, Quinn, and Valdés 2013). Emerging bilingual students therefore have an opportunity to use receptive and productive language to communicate and to negotiate meaning with others inside the science classroom. Teachers can promote and support the acquisition of a new language by simply using ADI to give emerging bilingual students an opportunity to *investigate* a phenomenon; *make sense* of that phenomenon; and *evaluate and refine* ideas, explanations, or arguments with others and then provide support and guidance as they learn how to communicate in a new language. We will discuss how teachers can use ADI to promote language development in greater detail in Chapter 1 and in Appendix 3.

Organization of This Book

This book is divided into six sections. Section 1 includes two chapters. The first chapter describes the ADI instructional model. The second chapter provides an overview of the information that is associated with each investigation. Sections 2–5 contain the 15 investigations. Each investigation includes three components:

- Teacher Notes, which provides information about the purpose of the lab and what teachers need to do to guide students through it.
- Investigation Handout, which can be photocopied and given to students at the beginning of the lesson. The handout provides the students with

a phenomenon to investigate, an overview of the DCI(s) and CCs that students can use during the investigation, and a guiding question to answer.

- Checkout Questions, which can be photocopied and given to students at the conclusion of the investigation. The Checkout Questions consist of items that target students' understanding of the DCI(s) and the CCs addressed during the lab.

Section 6 consists of six appendixes:

- Appendix 1 contains several standards alignment matrixes that can be used to assist with curriculum or lesson planning.
- Appendix 2 provides an overview of the CCs and nature of scientific knowledge (NOSK) and nature of scientific inquiry (NOSI) concepts that are a focus of the different investigations.
- Appendix 3 lists some frequently asked questions about ADI.
- Appendix 4 provides a peer-review guide and teacher scoring rubric, which can be photocopied and given to students.
- Appendix 5 provides a safety acknowledgment form, which can also be photocopied and given to students.
- Appendix 6 provides an answer guide for the Checkout Questions.

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Investigation 14

Movement of Water: Why Can We See the Roots of Trees That Grow Near Rivers or Streams?

Purpose

The purpose of this investigation is to give students an opportunity to use one disciplinary core idea (DCI), two crosscutting concepts (CCs), and seven scientific and engineering practices (SEPs) to figure out why trees that grow near rivers or streams often have exposed roots. Students will also learn about the difference between data and evidence during the reflective discussion.

Background Information About This Investigation

A tree is a plant with a trunk made of wood. The trunk of a tree supports branches that hold leaves above the ground. A tree also has roots. The roots of a tree anchor it to the ground. The roots also enable the tree to collect water and nutrients from the soil around it. Trees need water to survive, and the amount of water available at a particular location determines how many and what types of trees are found at that location. People usually cannot see the roots of trees because they grow in the soil. However, trees that grow near a body of water such as a lake, river, or stream often have exposed roots.

The water found in lakes, rivers, and streams comes from rain and snow. The amount of rain or snow that falls in an area determines the size of the lakes, rivers, and streams in that area. When there is a lot of rain or snow, lakes, rivers, and streams will fill with water and grow bigger and deeper. When there is very little rain or snow, lakes, rivers, and streams in the area will shrink in size and may even disappear. Water moving in a river or stream can break rocks and soils into smaller pieces and move the smaller pieces from one place to another. The movement of soil from one location to another by water is called *water erosion.*

When there is flooding in an area due to increased amounts of rain or melting snow, water levels will often rise and cover the base of trees that are located near the bank of a lake, river, or stream. The movement of water around the base of the trees can move the soil that is found there to a different location. The movement of water during a flood can therefore change the appearance of the land in an area through the process of erosion and leave trees with exposed roots.

The DCI, CCs, and SEPs That Students Use During This Investigation

DCI

- *ESS2.A: Earth Materials and Systems:* Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

CCs

- *CC 2: Cause and Effect:* Cause-and-effect relationships are routinely identified, tested, and used to explain change. Events that occur together with regularity might or might not be a cause-and-effect relationship.
- *CC 7: Stability and Change:* Change is measured in terms of differences over time and may occur at different rates. Some systems appear stable, but over long periods of time will eventually change.

SEPs

- *SEP 1: Asking Questions and Defining Problems*: Ask questions about what would happen if a variable is changed. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.
- *SEP 3: Planning and Carrying Out Investigations:* Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. Evaluate appropriate methods and/or tools for collecting data.
- *SEP 4: Analyzing and Interpreting Data:* Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
- *SEP 5: Using Mathematics and Computational Thinking*: Organize simple data sets to reveal patterns that suggest relationships. Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.
- *SEP 6: Constructing Explanations and Designing Solutions*: Construct an explanation of observed relationships. Use evidence to construct or support an explanation. Identify the evidence that supports particular points in an explanation.
- *SEP 7: Engaging in Argument From Evidence*: Compare and refine arguments based on an evaluation of the evidence presented. Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.

- *SEP 8: Obtaining, Evaluating, and Communicating Information*: Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas. Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.

Other Concepts That Students May Use During This Investigation

Students might also use some of the following concepts:

- A tree is a plant with a trunk made of wood. The trunk of a tree supports branches that hold leaves above the ground.
- The roots of a tree anchor it to the ground. The roots also enable the tree to collect water and nutrients from the soil around it.
- The water found in lakes, rivers, and streams comes from rain and snow.
- The amount of rain or snow that falls in an area determines the size of the lakes, rivers, and streams in the area. When there is a lot of rain or snow, lakes, rivers, and streams will fill with water and grow bigger and deeper. When there is very little rain or snow, the lakes, rivers, and streams in the area will shrink in size and may even disappear.
- Water moving in a river or stream can break rocks and soils into smaller pieces and move the smaller pieces from one place to another. Water can therefore change the appearance of the land in a region.

What Students Figure Out

Roots of trees grow into the soil, but soil by rivers or streams can be washed away. As moving water erodes the soil around the roots, they become exposed.

Timeline

The time needed to complete this investigation is 270 minutes (4 hours and 30 minutes). The amount of instructional time needed for each stage of the investigation is as follows:

- *Stage 1.* Introduce the task and the guiding question: 50 minutes
- *Stage 2.* Design a method and collect data: 45 minutes
- *Stage 3.* Create a draft argument: 40 minutes
- *Stage 4.* Argumentation session: 30 minutes
- *Stage 5.* Reflective discussion: 15 minutes

- *Stage 6.* Write a draft report: 30 minutes
- *Stage 7.* Peer review: 30 minutes
- *Stage 8.* Revise the report: 30 minutes

This investigation can be completed in one day or over eight days (one day for each stage) during your designated science time in the daily schedule.

Materials and Preparation

The materials needed for this investigation are listed in Table 14.1. The pictures of trees and grid paper are available on the book's Extras page at *www.nsta.org/adi-4th.*The other materials can be purchased at a big-box retail store such as Home Depot or Target or through an online retailer such as Amazon. The materials for this investigation can also be purchased as a complete kit (which includes enough materials for 24 students, or six groups) at *www.argumentdriveninquiry.com*.

TABLE 14.1

Materials for Investigation 14

Item	Quantity
Safety glasses or goggles	1 per student
Pictures of trees (set of 4)	1 per group
Plant tray (without holes)	1 per group
Wood block, 4" × 2" × 2"	1 per group
Pipe cleaners	10 per group
Funnel pitcher, 3.5-cup	1 per group
Ruler	2 per group
Stopwatch	1 per group
1 cm grid transparency	2 per group
Wet-erase markers	2 per group
Water	As needed per group
Sand	2 cups per group
Whiteboard, 2' × 3'*	1 per group
Investigation Handout	1 per student
Peer-review guide and teacher scoring rubric	1 per student
Checkout Questions (optional)	1 per student

*As an alternative, students can use computer and presentation software such as Microsoft PowerPoint or Apple Keynote to create their arguments.

To answer the guiding question, students will need to create a physical model of a tree-lined river or stream using a stream table. The plant tray will serve as the base of the stream table. One edge of the plant tray can be propped up on a small block of wood (or any other similar object) to create a gentle slope. This will allow water to flow downhill as it would on Earth's surface. You may choose to drill holes along the bottom edge of the tray to allow water to flow out. This is not necessary, but if you choose to do so, be sure to place a bucket or other container under the holes to collect the water as it flows out of the tray. You can also choose to plug the holes when students add water to the tray and then unplug them to simulate how lakes fill and then drain over time.

Students can use sand to simulate sediment along a river or stream, and they can use pipe cleaners to create model trees with roots. Students have many options for creating water flow in their physical models. They can add a specific volume of water into the funnel pitcher and then pour the water into their physical model. They can choose to pour a specific amount of water over a given interval of time or just pour different amounts of water in different spots. Students may need to rebuild their model to collect additional data. Rulers and 1 cm grid transparencies may be used to track the movement of sand or to track the collection of water in a given area. Rulers can measure distance between any two parts of the model, and the 1 cm grid transparencies can be used to record area. It is important to remember that, although you will help students set up the model, students will be making the decisions about how to collect data and what type of data to collect to answer the guiding question.

We recommend that you practice measuring the effect of flowing water on sediment before you have your students begin this investigation. It is important that you understand how to do it so you can demonstrate it for your students and help them when they get stuck.

Be sure to use a set routine for distributing and collecting the materials. One option is to organize the materials into kits that you can deliver to each group. A second option is to have all the materials on a table or cart at a central location. You can then assign a member of each group to be the "materials manager." This individual is responsible for collecting all the materials his or her group needs from the table or cart during class and for returning all the materials at the end of the class.

Safety Precautions

Remind students to follow all normal investigation safety rules. In addition, tell the students to take the following safety precautions:

- Wear sanitized safety glasses or goggles during setup, investigation activity, and cleanup.
- Do not throw pipe cleaners or sand, and do not put these materials in their mouth.

- Immediately clean up any spills to avoid a slip or fall hazard.
- Wash their hands with soap and water when done collecting the data.

Lesson Plan by Stage

Stage 1: Introduce the Task and the Guiding Question (50 minutes)

1. Ask the students to sit in six groups, with three or four students in each group.
2. Ask students to clear off their desks except for a pencil (and their *Student Workbook for Argument-Driven Inquiry in Fourth-Grade Science* if they have one).
3. Pass out an Investigation Handout to each student (or ask students to turn to Investigation Log 14 in their workbook).
4. Read the first paragraph of the "Introduction" aloud to the class. Ask the students to follow along as you read.
5. Pass out pictures of trees with exposed and covered roots to each group.
6. Tell the students to record their observations about the structures of the trees, their roots, and their environments and any questions they have about them in the "OBSERVED/WONDER" chart in the "Introduction" section of their Investigation Handout (or the investigation log in their workbook).
7. After students have recorded their observations and questions, ask students to share *what they observed* about the trees.
8. Ask students to share *what questions they have* about the trees.
9. Tell the students, "Some of your questions might be answered by reading the rest of the 'Introduction.'"
10. Ask the students to read the rest of the "Introduction" on their own *or* ask them to follow along as you read the rest aloud.
11. Once the students have read the rest of the "Introduction," ask them to fill out the "KNOW/NEED" chart on their Investigation Handout (or in their investigation log) as a group.
12. Ask students to share what they learned from the reading. Add these ideas to a class "know / need to figure out" chart.
13. Ask students to share what they think they will need to figure out based on what they read. Add these ideas to the class "know / need to figure out" chart.
14. Tell the students, "It looks like we have something to figure out. Let's see what we will need to do during our investigation."
15. Read the task and the guiding question aloud.
16. Tell the students, "I have lots of materials here that you can use."
17. Introduce the students to the materials available for them to use during the investigation by showing them how they can create a model of a tree-lined

river or stream. Then give students an opportunity to ask questions about the method. It's important for students to know what the stream table looks like and how it works so that they can use it to answer the guiding question. Be sure to ask students what each part of the model might represent.

18. Collect the pictures of the trees from the students before beginning the next stage.

Stage 2: Design a Method and Collect Data (45 minutes)

1. Tell the students, "I am now going to give you and the other members of your group about 15 minutes to plan your investigation. Before you begin, I want you all to take a couple of minutes to discuss the following questions with the rest of your group."
2. Show the following questions on the screen or board:
   - What might *cause* the appearance of the trees near rivers or streams to *change?*
   - How can we *measure a change* over time?
3. Tell the students, "Please take a few minutes to come up with an answer to these questions." Give the students two or three minutes to discuss these two questions.
4. Ask two or three different groups to share their answers. Be sure to highlight or write down any important ideas on the board so students can refer to them later.
5. If possible, use a document camera to project an image of the graphic organizer for this investigation on a screen or board (or take a picture of it and project the picture on a screen or board). Tell the students, "I now want you all to plan out your investigation. To do that, you will need to create an investigation proposal by filling out this graphic organizer."
6. Point to the box labeled "Our guiding question:" and tell the students, "You can put the question we are trying to answer in this box." Then ask, "Where can we find the guiding question?"
7. Wait for a student to answer where to find the guiding question (the answer is "in the handout").
8. Point to the box labeled "This is a picture of how we will set up the equipment:" and tell the students, "You can draw a picture in this box of how you will set up the equipment to carry out this investigation."
9. Point to the box labeled "We will collect the following data:" and tell the students, "You can list the measurements or observations that you will need to collect during the investigation in this box."

10. Point to the box labeled "These are the steps we will follow to collect data:" and tell the students, "You can list what you are going to do to collect the data you need and what you will do with your data once you have it. Be sure to give enough detail that I could do your investigation for you."
11. Ask the students, "Do you have any questions about what you need to do?"
12. Answer any questions that come up.
13. Tell the students, "Once you are done, raise your hand and let me know. I'll then come by and look over your proposal and give you some feedback. You may not begin collecting data until I have approved your proposal by signing it. You need to have your proposal done in the next 15 minutes."
14. Give the students 15 minutes to work in their groups on their investigation proposal. As they work, move from group to group to check in, ask probing questions, and offer a suggestion if a group gets stuck.

What should a student-designed investigation look like?

The students' investigation proposal should include the following information:

- The guiding question is "Why can we see the roots of trees that grow near rivers or streams?"
- Students can collect data about (1) the amount of water they add, (2) the amount of sand that moved, (3) how the width of the riverbed changes, and (4) how much of the tree roots can be seen.
- The steps that the students will follow to collect the data should reflect the measurements that they decide to examine. However, a procedure might include the following steps:
    1. Set up a model of a tree-lined river.
    2. Trace the width of the riverbed on the grid transparency.
    3. Measure 1 cup of water in the funnel pitcher.
    4. Pour the water onto the stream table.
    5. Trace the width of the river bed on the grid transparency.
    6. Repeat steps 1–5 using a different volume of water.

This is just one example of how they can collect the data, and there should be a lot of variation in the student-designed investigations.

15. As each group finishes its investigation proposal, be sure to read it over and determine if it will be productive or not. If you feel the investigation will be productive (not necessarily what you would do or what the other groups are

doing), sign your name on the proposal and let the group start collecting data. If the plan needs to be changed, offer some suggestions or ask some probing questions, and have the group make the changes before you approve it.

16. Pass out the materials or have one student from each group collect the materials they need from a central supply table or cart for the groups that have an approved proposal.
17. Be sure to remind students of the safety rules and the safety precautions for this investigation.
18. Give the students 15 minutes to collect their data.
19. Be sure to collect the materials and have the students clean up before asking them to analyze their data.

Stage 3: Create a Draft Argument (40 minutes)

1. Tell the students, "Now that we have all this data, we need to analyze the data so we can figure out an answer to the guiding question."
2. If possible, project an image of the "Analyze Your Data" section for this investigation on a screen or board using a document camera (or take a picture of it and project the picture on a screen or board). Point to the section and tell the students, "You can create a graph as a way to analyze your data. You can make your graph in this section."
3. Ask the students, "What information do we need to include in these graphs?"
4. Tell the students, "Please take a few minutes to discuss this question with your group, and be ready to share."
5. Give the students five minutes to discuss.
6. Ask two or three different groups to share their answers. Be sure to highlight or write down any important ideas on the board so students can refer to them later.
7. Tell the students, "I am now going to give you and the other members of your group about 10 minutes to analyze your data."
8. Give the students 10 minutes to analyze their data. As they work, move from group to group to check in, ask probing questions, and offer suggestions.

What should a graph look like for this investigation?

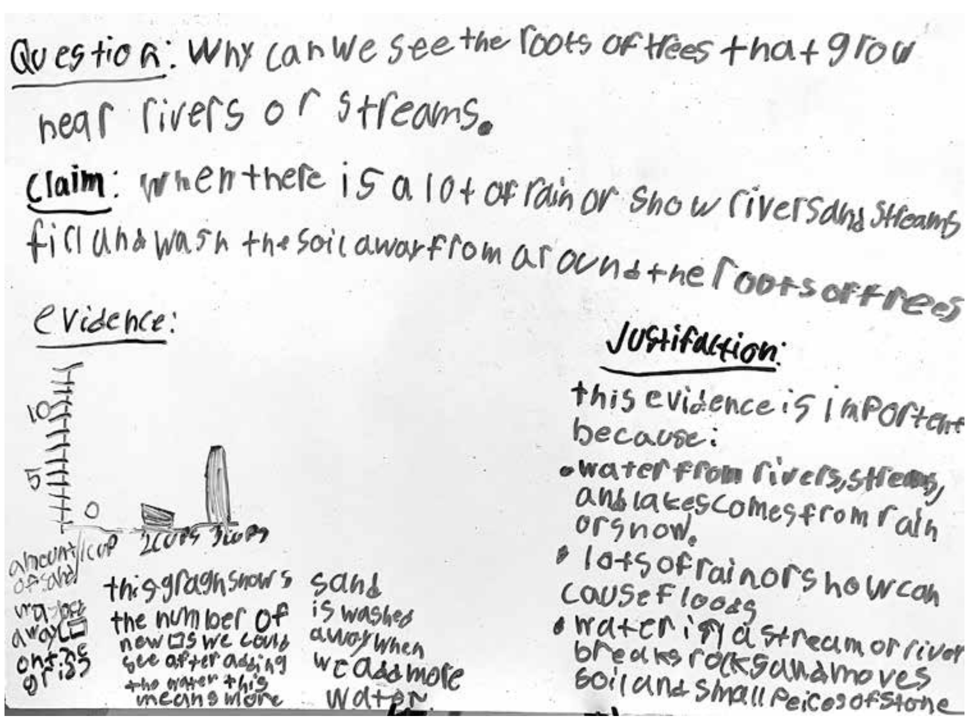
There are a number of different ways that students can analyze the observations or measurements they collect during this investigation. One of the most straightforward ways is to create a bar graph with the volume of water poured on the stream table on the horizontal or *x*-axis and the change in the river width on the vertical or *y*-axis. An example of a graph can be seen in Figure 14.1 (p. 560). There are other options for analyzing the collected data. Students often come up with some unique ways of analyzing their data, so be sure to give them some voice and choice during this stage.

9. Tell the students, "I am now going to give you and the other members of your group 15 minutes to create an argument to share what you have learned and convince others that they should believe you. Before you do that, we need to take a few minutes to discuss what you need to include in your argument."
10. If possible, use a document camera to project the "Argument Presentation on a Whiteboard" image from the Investigation Handout (or the investigation log in their workbook) on a screen or board (or take a picture of it and project the picture on a screen or board).
11. Point to the box labeled "The Guiding Question:" and tell the students, "You can put the question we are trying to answer here on your whiteboard."
12. Point to the box labeled "Our Claim:" and tell the students, "You can put your claim here on your whiteboard. The claim is your answer to the guiding question."
13. Point to the box labeled "Our Evidence:" and tell the students, "You can put the evidence that you are using to support your claim here on your whiteboard. Your evidence will need to include the analysis you just did and an explanation of what your analysis means or shows. Scientists always need to support their claims with evidence."
14. Point to the box labeled "Our Justification of the Evidence:" and tell the students, "You can put your justification of your evidence here on your whiteboard. Your justification needs to explain why your evidence is important. Scientists often use core ideas to explain why the evidence they are using matters. Core ideas are important concepts that scientists use to help them make sense of what happens during an investigation."
15. Ask the students, "What are some core ideas that we read about earlier that might help us explain why the evidence we are using is important?"

16. Ask students to share some of the core ideas from the “Introduction” section of the Investigation Handout (or the investigation log in the workbook). List these core ideas on the board.
17. Tell the students, “That is great. I would like to see everyone try to include these core ideas in your justification of the evidence. Your goal is to use these core ideas to help explain why your evidence matters and why the rest of us should pay attention to it.”
18. Ask the students, “Do you have any questions about what you need to do?”
19. Answer any questions that come up.
20. Tell the students, “Okay, go ahead and start working on your arguments. You need to have your argument done in the next 15 minutes. It doesn’t need to be perfect. We just need something down on the whiteboards so we can share our ideas.”
21. Give the students 15 minutes to work in their groups on their arguments. As they work, move from group to group to check in, ask probing questions, and offer a suggestion if a group gets stuck. Figure 14.1 shows an example of an argument for this investigation.

FIGURE 14.1

Example of an argument



Stage 4: Argumentation Session (30 minutes)

The argumentation session can be conducted in a whole-class presentation format, a gallery walk format, or a modified gallery walk format. We recommend using a whole-class presentation format for the first investigation, but try to transition to either the gallery walk or modified gallery walk format as soon as possible because that will maximize student voice and choice inside the classroom. The following list shows the steps for the three formats; unless otherwise noted, the steps are the same for all three formats.

1. Begin by introducing the use of the whiteboard.
   - *If using the whole-class presentation format,* tell the students, "We are now going to share our arguments. Please set up your whiteboards so everyone can see them."
   - *If using the gallery walk or modified gallery walk format,* tell the students, "We are now going to share our arguments. Please set up your whiteboards so they are facing the walls."
2. Allow the students to set up their whiteboards.
   - *If using the whole-class presentation format,* the whiteboards should be set up on stands or chairs so they are facing toward the center of the room.
   - *If using the gallery walk or modified gallery walk format,* the whiteboards should be set up on stands or chairs so they are facing toward the outside of the room.
3. Give the following instructions to the students:
   - *If using the whole-class presentation format or the modified gallery walk format*, tell the students, "Okay, before we get started I want to explain what we are going to do next. I'm going to ask some of you to present your arguments to your classmates. If you are presenting your argument, your job is to share your group's claim, evidence, and justification of the evidence. The rest of you will be reviewers. If you are a reviewer, your job is to listen to the presenters, ask the presenters questions if you do not understand something, and then offer them some suggestions about ways to make their argument better. After we have a chance to learn from each other, I'm going to give you some time to revise your arguments and make them better."
   - *If using the gallery walk format*, tell the students, "Okay, before we get started I want to explain what we are going to do next. You are going to have an opportunity to read the arguments that were created by other groups. Your group will go to a different group's argument. I'll give you a few minutes to read it and review it. Your job is to offer them some suggestions about ways to make their argument better. You can use sticky notes to give them suggestions. Please be specific about what you want to change and how you think they should change it. After we have a chance to learn from each other, I'm going to give you some time to revise your arguments and make them better."

4. Use a document camera to project the "Ways to IMPROVE our argument …" box from the Investigation Handout (or the investigation log in their workbook) on a screen or board (or take a picture of it and project the picture on a screen or board).
   - *If using the whole-class presentation format or the modified gallery walk format,* point to the box and tell the students, "If you are a presenter, you can write down the suggestions you get from the reviewers here. If you are a reviewer and you see a good idea from another group, you can write down that idea here. Once we are done with the presentations, I will give you a chance to use these suggestions or ideas to improve your arguments.
   - *If using the gallery walk format,* point to the box and tell the students, "If you see a good idea from another group, you can write it down here. Once we are done reviewing the different arguments, I will give you a chance to use these ideas to improve your own arguments. It is important to share ideas like this."

   Ask the students, "Do you have any questions about what you need to do?"
5. Answer any questions that come up.
6. Give the following instructions:
   - *If using the whole-class presentation format,* tell the students, "Okay. Let's get started."
   - *If using the gallery walk format,* tell the students, "Okay, I'm now going to tell you which argument to go to and review.
   - *If using the modified gallery walk format,* tell the students, "Okay, I'm now going to assign you to be a presenter or a reviewer." Assign one or two students from each group to be presenters and one or two students from each group to be reviewers.
7. Begin the review of the arguments.
   - *If using the whole-class presentation format,* have four or five groups present their arguments one at a time. Give each group only two to three minutes to present their argument. Then give the class two to three minutes to ask them questions and offer suggestions. Be sure to encourage as much participation from the students as possible.
   - *If using the gallery walk format,* tell the students, "Okay. Let's get started. Each group, move one argument to the left. Don't move to the next argument until I tell you to move. Once you get there, read the argument and then offer suggestions about how to make it better. I will put some sticky notes next to each argument. You can use the sticky notes to leave your suggestions." Give each group about three to four minutes to read the arguments, talk, and offer suggestions.

     a. Tell the students, "Okay. Let's rotate. Move one group to the left."

b. Again, give each group three or four minutes to read, talk, and offer suggestions.

c. Repeat this process for two more rotations.

- *If using the modified gallery walk format,* tell the students, "Okay. Let's get started. Reviewers, move one group to the left. Don't move to the next group until I tell you to move. Presenters, go ahead and share your argument with the reviewers when they get there." Give each group of presenters and reviewers about three to four minutes to talk.

  a. Tell the students, "Okay. Let's rotate. Reviewers, move one group to the left."

  b. Again, give each group of presenters and reviewers about three or four minutes to talk.

  c. Repeat this process for two more rotations.

8. Tell the students to return to their workstations.
9. Give the following instructions about revising the argument:
   - *If using the whole-class presentation format,* tell the students, "I'm now going to give you about 10 minutes to revise your argument. Take a few minutes to talk in your groups and determine what you want to change to make your argument better. Once you have decided what to change, go ahead and make the changes to your whiteboard."
   - *If using the gallery walk format,* tell the students, "I'm now going to give you about 10 minutes to revise your argument. Take a few minutes to read the suggestions that were left at your argument. Then talk in your groups and determine what you want to change to make your argument better. Once you have decided what to change, go ahead and make the changes to your whiteboard."
   - *If using the modified gallery walk format,* "I'm now going to give you about 10 minutes to revise your argument. Please return to your original groups." Wait for the students to move back into their original groups and then tell the students, "Okay, take a few minutes to talk in your groups and determine what you want to change to make your argument better. Once you have decided what to change, go ahead and make the changes to your whiteboard."

   Ask the students, "Do you have any questions about what you need to do?"
10. Answer any questions that come up.
11. Tell the students, "Okay. Let's get started."
12. Give the students 10 minutes to work in their groups on their arguments. As they work, move from group to group to check in, ask probing questions, and offer a suggestion if a group gets stuck.

Stage 5: Reflective Discussion (15 minutes)

1. Tell the students, "We are now going take a minute to talk about what we did and what we have learned."
2. Show the image in Figure 14.2 on a screen.
3. Ask the students, "What do you all notice here?"
4. Allow students to share their ideas. Keep probing until someone says that it is a tree with exposed roots.
5. Ask the students, "What do you think might have caused the tree to look like this?"
6. Allow students to share their ideas. Keep probing until someone says that water moving in the river caused the sediment around the tree roots to be carried away.
7. Ask the students, "How can you be sure?"
8. Allow students to share their ideas. Keep probing until students describe what they observed during their investigation.
9. Ask the students, "Why isn't the sediment around the rest of the roots washed away in this picture?"
10. Allow students to share their ideas. Keep probing until someone says that the water level in the river is not high enough to reach the tree.
11. Ask the students, "Where would more water come from?"
12. Allow students to share their ideas. Keep probing until someone says that more water comes from heavy rain or rapid snow melt.
13. Tell the students, "Okay, let's make sure we are on the same page. Water can shape the land and affects the types of living things found in a region. Water can break rocks, soils, and sediments into smaller particles and move them around. This can result in trees having exposed roots by rivers and streams. The fact that moving water can change the appearance of land is a really important core idea in science."
14. Ask the students, "Does anyone have any questions about this core idea?"
15. Answer any questions that come up.

FIGURE 14.2

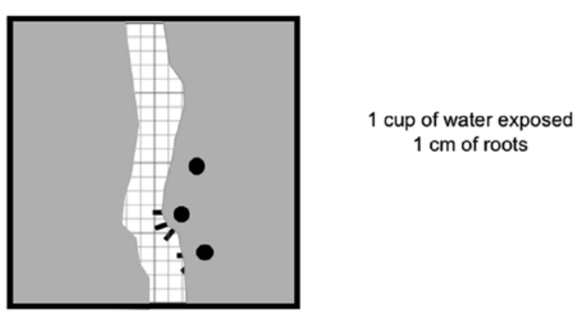
A tree by a stream with exposed roots

16. Tell the students, "We looked for cause-and-effect relationships during our investigation." Then ask, "Can anyone tell me why it is useful to look for cause-and-effect relationships during an investigation?"
17. Allow students to share their ideas.
18. Tell the students, "Looking for cause-and-effect relationships helps us explain how things work or predict what will happen in the future."
19. Ask the students, "What did we figure out today by looking for cause-and-effect relationships?"
20. Allow students to share their ideas. Keep probing until students agree that lots of flowing water will move sediment away from the roots of trees.
21. Tell the students, "Scientists will often study how the land changes over time." Then ask, "Can anyone tell me why it is useful to keep track of how land changes over time and under what conditions this change happens?"
22. Allow students to share their ideas.
23. Tell the students, "Studying systems when they are stable and when they are changing helps us understand how variable nature is. It also helps us to understand what has happened and what might happen next. We can also prepare for the future."
24. Tell the students, "We are now going take a minute to talk about what went well and what didn't go so well during our investigation. We need to talk about this because you are going to be planning and carrying your own investigations like this a lot this year, and I want to help you all get better at it."
25. Show an image of the question "What made your investigation scientific?" on the screen. Tell the students, "Take a few minutes to talk about how you would answer this question with the other people in your group. Be ready to share with the rest of the class." Give the students two to three minutes to talk in their group.
26. Ask the students, "What do you all think? Who would like to share an idea?"
27. Allow students to share their ideas. Be sure to expand on their ideas about what makes an investigation scientific.
28. Show an image of the question "What made your investigation not so scientific?" on the screen. Tell the students, "Take a few minutes to talk about how you would answer this question with the other people in your group. Be ready to share with the rest of the class." Give the students two to three minutes to talk in their group.
29. Ask the students, "What do you all think? Who would like to share an idea?"
30. Allow students to share their ideas. Be sure to expand on their ideas about what makes an investigation less scientific.

31. Show an image of the question "What rules can we put into place to help us make sure our next investigation is more scientific?" on the screen. Tell the students, "Take a few minutes to talk about how you would answer this question with the other people in your group. Be ready to share with the rest of the class." Give the students two to three minutes to talk in their group.
32. Ask the students, "What do you all think? Who would like to share an idea?"
33. Allow students to share their ideas. Once they have shared their ideas, offer a suggestion for a possible class rule.
34. Ask the students, "What do you all think? Should we make this a rule?"
35. If the students agree, write the rule on the board or a class "Rules for Scientific Investigation" chart so you can refer to it during the next investigation.
36. Tell the students, "We are now going take a minute to talk about different types of information in science."
37. Show an image of the question "What is the difference between data and evidence in science?" on the screen. Tell the students, "Take a few minutes to talk about how you would answer this question with the other people in your group. Be ready to share with the rest of the class." Give the students two to three minutes to talk in their group.
38. Ask the students, "What do you all think? Who would like to share an idea?"
39. Allow students to share their ideas.
40. Tell the students, "Okay, let's make sure we are all using the same definition. *Data* are observations or measurements that we collect during an investigation. *Evidence* is an analysis of the data we collected and an interpretation of that analysis."
41. Show the image in Figure 14.3 on the screen.

FIGURE 14.3

A stream table from above with an observation



42. Ask the students, "Is this statement data or evidence and why?"

43. Allow students to share their ideas.
44. Tell the students, "This statement is data because it is a measurement."
45. Show the image in Figure 14.4 on the screen.
46. Ask the students, "Is this graph data or evidence and why?"
47. Allow students to share their ideas.
48. Tell the students, "This graph is an analysis of data but there is no interpretation of that analysis, so it is still not evidence."
49. Show the image in Figure 14.5 on the screen.
50. Ask the students, "Is this information data or evidence and why?"
51. Allow students to share their ideas.
52. Tell the students, "This is an example of evidence because it includes an analysis of the data and an interpretation of an analysis."
53. Ask the students, "Does anyone have any questions about the difference between data and evidence?"
54. Answer any questions that come up.

FIGURE 14.4

A stream table from above with an analysis of data

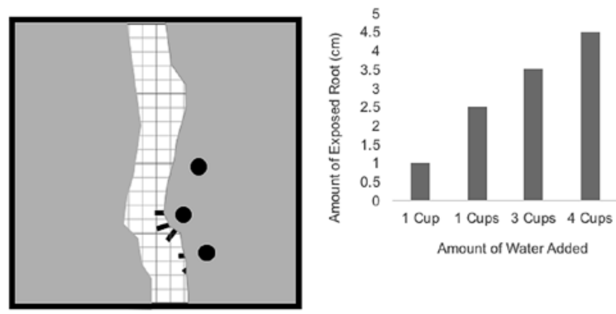
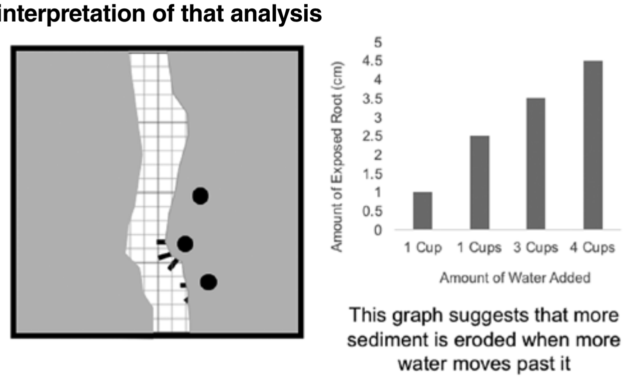


FIGURE 14.5

A stream table from above with an analysis of data and an interpretation of that analysis



Stage 6: Write a Draft Report (30 minutes)

Your students will use either the Investigation Handout or the investigation log in the student workbook when writing the draft report. When you give the directions shown in quotes in the following steps, substitute "investigation log" (as shown in brackets) for "handout" if they are using the workbook.

1. Tell the students, "You are now going to write an investigation report to share what you have learned. Please take out a pencil and turn to the 'Draft Report' section of your handout [investigation log]."
2. If possible, use a document camera to project the "Introduction" section of the draft report from the Investigation Handout (or the investigation log in their workbook) on a screen or board (or take a picture of it and project the picture on a screen or board).

3. Tell the students, "The first part of the report is called the 'Introduction.' In this section of the report you want to explain to the reader what you were investigating, why you were investigating it, and what question you were trying to answer. All of this information can be found in the text at the beginning of your handout [investigation log]." Point to the image and say, "There are some sentence starters here to help you begin writing the report." Ask the students, "Do you have any questions about what you need to do?"
4. Answer any questions that come up.
5. Tell the students, "Okay. Let's write."
6. Give the students 10 minutes to write the "Introduction" section of the report. As they work, move from student to student to check in, ask probing questions, and offer a suggestion if a student gets stuck.
7. If possible, use a document camera to project the "Method" section of the draft report from the Investigation Handout (or the investigation log in their workbook) on a screen or board (or take a picture of it and project the picture on a screen or board).
8. Tell the students, "The second part of the report is called the 'Method.' In this section of the report you want to explain to the reader what you did during the investigation, what data you collected and why, and how you went about analyzing your data. All of this information can be found in the 'Plan Your Investigation' section of your handout [investigation log]. Remember that you all planned and carried out different investigations, so do not assume that the reader will know what you did." Point to the image and say, "There are some sentence starters here to help you begin writing this part of the report." Ask the students, "Do you have any questions about what you need to do?"
9. Answer any questions that come up.
10. Tell the students, "Okay. Let's write."
11. Give the students 10 minutes to write the "Method" section of the report. As they work, move from student to student to check in, ask probing questions, and offer a suggestion if a student gets stuck.
12. If possible, use a document camera to project the "Argument" section of the draft report from the Investigation Handout (or the investigation log in their workbook) on a screen or board (or take a picture of it and project the picture on a screen or board).
13. Tell the students, "The last part of the report is called the 'Argument.' In this section of the report you want to share your claim, evidence, and justification of the evidence with the reader. All of this information can be found on your whiteboard." Point to the image and say, "There are some sentence starters here to help you begin writing this part of the report." Ask the students, "Do you have any questions about what you need to do?"

14. Answer any questions that come up.
15. Tell the students, "Okay. Let's write."
16. Give the students 10 minutes to write the "Argument" section of the report. As they work, be sure to move from student to student to check in, ask probing questions, and offer a suggestion if a student gets stuck.

Stage 7: Peer Review (30 minutes)

Your students will use either the Investigation Handout or the investigation log in the student workbook when doing the peer review. When you give the directions shown in quotes in the following steps, substitute "workbook" (as shown in brackets) for "Investigation Handout" if they are using the workbook.

1. Tell the students, "We are now going to review our reports to find ways to make them better. I'm going to come around and collect your Investigation Handout [workbook]. While I do that, please take out a pencil."
2. Collect the Investigation Handouts or workbooks from the students.
3. If possible, use a document camera to project the peer-review guide (PRG; see Appendix 4) on a screen or board (or take a picture of it and project the picture on a screen or board).
4. Tell the students, "We are going to use this peer-review guide to give each other feedback." Point to the image.
5. Give the following instructions:
    - *If using the Investigation Handout,* tell the students, "I'm going to ask you to work with a partner to do this. I'm going to give you and your partner a draft report to read and a peer-review guide to fill out. You two will then read the report together. Once you are done reading the report, I want you to answer each of the questions on the peer-review guide." Point to the review questions on the image of the PRG.
    - *If using the workbook,* tell the students, "I'm going to ask you to work with a partner to do this. I'm going to give you and your partner a draft report to read. You two will then read the report together. Once you are done reading the report, I want you to answer each of the questions on the peer-review guide that is right after the report in the investigation log." Point to the review questions on the image of the PRG.
6. Tell the students, "You can check 'yes,' 'almost,' or 'no' after each question." Point to the checkboxes on the image of the PRG.
7. Tell the students, "This will be your rating for this part of the report. Make sure you agree on the rating you give the author. If you mark 'almost' or 'no,' then

you need to tell the author what he or she needs to do to get a 'yes.'" Point to the space for the reviewer feedback on the image of the PRG.

8. Tell the students, "It is really important for you to give the authors feedback that is helpful. That means you need to tell them exactly what they need to do to make their report better." Ask the students, "Do you have any questions about what you need to do?"
9. Answer any questions that come up.
10. Tell the students, "Please sit with a partner who is not in your current group." Allow the students time to sit with a partner.
11. Give the following instructions:
    - *If using the Investigation Handout,* tell the students, "Okay, I am now going to give you one report to read and one peer-review guide to fill out." Pass out one report to each pair. Make sure that the report you give a pair was not written by one of the students in that pair. Give each pair one PRG to fill out as a team.
    - *If using the workbook,* tell the students, "Okay, I am now going to give you one report to read." Pass out a workbook to each pair. Make sure that the workbook you give a pair is not from one of the students in that pair.
12. Tell the students, "Okay, I'm going to give you 15 minutes to read the report I gave you and to fill out the peer-review guide. Go ahead and get started."
13. Give the students 15 minutes to work. As they work, move around from pair to pair to check in and see how things are going, answer questions, and offer advice.
14. After 15 minutes pass, tell the students, "Okay, time is up." *If using the Investigation Handout,* say, "Please give me the report and the peer-review guide that you filled out." *If using the workbook,* say, "Please give me the workbook that you have."
15. Collect the Investigation Handouts and the PRGs, or collect the workbooks if they are being used. Be sure you keep the handout and the PRG together.
16. Give the following instructions:
    - *If using the Investigation Handout,* tell the students, "Okay, I am now going to give you a different report to read and a new peer-review guide to fill out." Pass out another report to each pair. Make sure that this report was not written by one of the students in that pair. Give each pair a new PRG to fill out as a team.
    - *If using the workbook,* tell the students, "Okay, I am now going to give you a different report to read." Pass out a different workbook to each pair. Make sure that the workbook you give a pair is not from one of the students in that pair.

17. Tell the students, "Okay, I'm going to give you 15 minutes to read this new report and to fill out the peer-review guide. Go ahead and get started."
18. Give the students 15 minutes to work. As they work, move around from pair to pair to check in and see how things are going, answer questions, and offer advice.
19. After 15 minutes pass, tell the students, "Okay, time is up." *If using the Investigation Handout*, say, "Please give me the report and the peer-review guide that you filled out." *If using the workbook,* say, "Please give me the workbook that you have."
20. Collect the Investigation Handouts and the PRGs, or collect the workbooks if they are being used. Be sure you keep the handout and the PRG together.

Stage 8: Revise the Report (30 minutes)

Your students will use either the Investigation Handout or the investigation log in the student workbook when revising the report. Except where noted below, the directions are the same whether using the handout or the log.

1. Give the following instructions:
   - *If using the Investigation Handout,* tell the students, "You are now going to revise your investigation report based on the feedback you get from your classmates. Please take out a pencil while I hand back your draft report and the peer-review guide."
   - *If using the investigation log in the student workbook,* tell the students, "You are now going to revise your investigation report based on the feedback you get from your classmates. Please take out a pencil while I hand back your investigation logs."
2. *If using the Investigation Handout,* pass back the handout and the PRG to each student. *If using the investigation log,* pass back the log to each student.
3. Tell the students, "Please take a few minutes to read over the peer-review guide. You should use it to figure out what you need to change in your report and how you will change the report."
4. Allow the students time to read the PRG.
5. *If using the investigation log,* if possible use a document camera to project the "Write Your Final Report" section from the investigation log on a screen or board (or take a picture of it and project the picture on a screen or board).
6. Give the following instructions:
   - *If using the Investigation Handout,* tell the students, "Okay. Let's revise our reports. Please take out a piece of paper. I would like you to rewrite your

report. You can use your draft report as a starting point, but use the feedback on the peer-review guide to help make it better."

- *If using the investigation log,* tell the students, "Okay. Let's revise our reports. I would like you to rewrite your report in the section of the investigation log that says 'Write Your Final Report.'" Point to the image on the screen and tell the students, "You can use your draft report as a starting point, but use the feedback on the peer-review guide to help make your report better."

Ask the students, "Do you have any questions about what you need to do?"

7. Answer any questions that come up.
8. Tell the students, "Okay. Let's write."
9. Give the students 30 minutes to rewrite their report. As they work, move from student to student to check in, ask probing questions, and offer a suggestion if a student gets stuck.
10. Give the following instructions:
    - *If using the Investigation Handout,* tell the students, "Okay. Time's up. I will now come around and collect your Investigation Handout, the peer-review guide, and your final report."
    - *If using the investigation log,* tell the students, "Okay. Time's up. I will now come around and collect your workbooks."
11. *If using the Investigation Handout,* collect all the Investigation Handouts, PRGs, and final reports. *If using the investigation log,* collect all the workbooks.
12. *If using the Investigation Handout,* use the "Teacher Score" columns in the PRG to grade the final report. *If using the investigation log,* use the "Investigation Report Grading Rubric" in the investigation log to grade the final report. Whether you are using the handout or the log, you can give the students feedback about their writing in the "Teacher Comments" section.

How to Use the Checkout Questions

The Checkout Questions are an optional assessment. We recommend giving them to students one day after they finish stage 8 of the ADI investigation. Appendix 6 provides an answer guide for the Checkout Questions.

The Checkout Questions can be used as a formative or summative assessment of student thinking. If you plan to use them as a formative assessment, we recommend that you look over the student answers to determine if you need to reteach the core idea and/or crosscutting concept from the investigation, but do not grade them. If you plan to use them as a summative assessment, we have included a Teacher Scoring Rubric at the end of the Checkout Questions that you can use to score a student's ability to apply the core idea in a new scenario and explain their use of a crosscutting concept; see Figure 14.6

for an example of the rubric. The rubric includes a 4-point scale that ranges from 0 (the student cannot apply the core idea correctly in all cases and cannot explain the crosscutting concept) to 3 (the student can apply the core idea correctly in all cases and can fully explain the crosscutting concept).

FIGURE 14.6

Example of a Teacher Scoring Rubric with cause and effect as the crosscutting concept

Level	Description
3	The student can apply the core idea correctly in all cases and can fully explain the cause-and-effect relationship.
2	The student can apply the core idea correctly in all cases but cannot fully explain the cause-and-effect relationship.
1	The student cannot apply the core idea correctly in all cases but can fully explain the cause-and-effect relationship.
0	The student cannot apply the core idea correctly in all cases and cannot explain the cause-and-effect relationship.

The Checkout Questions, regardless of how you decide to use them, are a great way to make student thinking visible so you can determine if the students have learned the core idea and the crosscutting concept.

Connections to Standards

Table 14.2 highlights how the investigation can be used to address specific performance expectations from the *NGSS, Common Core State Standards (CCSS)* in English language arts (ELA) and in mathematics, and *English Language Proficiency (ELP) Standards.*

TABLE 14.2

Investigation 14 alignment with standards

***NGSS* performance expectations**	Strong alignment • 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. Moderate alignment • 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.

Continued

Table 14.2 (*continued*)

***CCSS ELA*—Reading: Informational Text**	Key ideas and details • CCSS.ELA-LITERACY.RI.4.1: Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. • CCSS.ELA-LITERACY.RI.4.2: Determine the main idea of a text and explain how it is supported by key details; summarize the text. • CCSS.ELA-LITERACY.RI.4.3: Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. Craft and structure • CCSS.ELA-LITERACY.RI.4.4: Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a *grade 4 topic or subject area*. • CCSS.ELA-LITERACY.RI.4.5: Describe the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in a text or part of a text. • CCSS.ELA-LITERACY.RI.4.6: Compare and contrast a firsthand and secondhand account of the same event or topic; describe the differences in focus and the information provided. Integration of knowledge and ideas • CCSS.ELA-LITERACY.RI.4.7: Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. • CCSS.ELA-LITERACY.RI.4.8: Explain how an author uses reasons and evidence to support particular points in a text. • CCSS.ELA-LITERACY.RI.4.9: Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. Range of reading and level of text complexity • CCSS.ELA-LITERACY.RI.4.10: By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, in the grades 4-5 text complexity band proficiently, with scaffolding as needed at the high end of the range.
***CCSS ELA*—Writing**	Text types and purposes • CCSS.ELA-LITERACY.W.4.1: Write opinion pieces on topics or texts, supporting a point of view with reasons and information. 　○ CCSS.ELA-LITERACY.W.4.1.A: Introduce a topic or text clearly, state an opinion, and create an organizational structure in which related ideas are grouped to support the writer's purpose. 　○ CCSS.ELA-LITERACY.W.4.1.B: Provide reasons that are supported by facts and details. 　○ CCSS.ELA-LITERACY.W.4.1.C: Link opinion and reasons using words and phrases (e.g., *for instance*, *in order to*, *in addition*).

Continued

Table 14.2 (*continued*)

***CCSS ELA*—Writing** (*continued*)	○ CCSS.ELA-LITERACY.W.4.1.D: Provide a concluding statement or section related to the opinion presented. • CCSS.ELA-LITERACY.W.4.2: Write informative / explanatory texts to examine a topic and convey ideas and information clearly. ○ CCSS.ELA-LITERACY.W.4.2.A: Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension. ○ CCSS.ELA-LITERACY.W.4.2.B: Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic. ○ CCSS.ELA-LITERACY.W.4.2.C: Link ideas within categories of information using words and phrases (e.g., *another*, *for example*, *also*, *because*). ○ CCSS.ELA-LITERACY.W.4.2.D: Use precise language and domain-specific vocabulary to inform about or explain the topic. ○ CCSS.ELA-LITERACY.W4.2.E: Provide a concluding statement or section related to the information or explanation presented. Production and distribution of writing • CCSS.ELA-LITERACY.W.4.4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. • CCSS.ELA-LITERACY.W.4.5: With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing. • CCSS.ELA-LITERACY.W.4.6: With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting. Research to build and present knowledge • CCSS.ELA-LITERACY.W.4.7: Conduct short research projects that build knowledge through investigation of different aspects of a topic. • CCSS.ELA-LITERACY.W.4.9: Draw evidence from literary or informational texts to support analysis, reflection, and research. Range of writing • CCSS.ELA-LITERACY.W.4.10: Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Continued

Table 14.2 (*continued*)

CCSS ELA— **Speaking and Listening**	Comprehension and collaboration
	• CCSS.ELA-LITERACY.SL.4.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.
	  ○ CCSS.ELA-LITERACY.SL.4.1.A: Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
	  ○ CCSS.ELA-LITERACY.SL.4.1.B: Follow agreed-upon rules for discussions and carry out assigned roles.
	  ○ CCSS.ELA-LITERACY.SL.4.1.C: Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.
	  ○ CCSS.ELA-LITERACY.SL.4.1.D: Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.
	• CCSS.ELA-LITERACY.SL.4.2: Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
	• CCSS.ELA-LITERACY.SL.4.3: Identify the reasons and evidence a speaker provides to support particular points
	Presentation of knowledge and ideas
	• CCSS.ELA-LITERACY.SL.4.4: Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
	• CCSS.ELA-LITERACY.SL.4.5: Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.
	• CCSS.ELA-LITERACY.SL.4.6: Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation.

CCSS Mathematics— **Number and Operations in Base Ten**	Use place value understanding and properties of operations to perform multi-digit arithmetic. • CCSS.MATH.CONTENT.4.NBT.B.4: Fluently add and subtract multi-digit whole numbers using the standard algorithm.

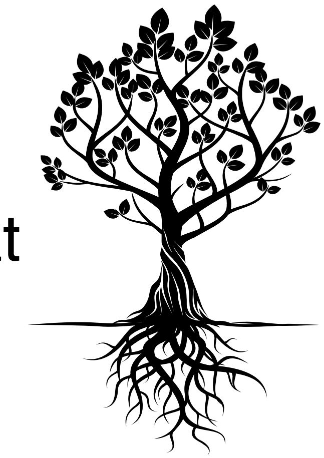
Continued

Table 14.2 (*continued*)

***CCSS Mathematics—* Measurement and Data**	Solve problems involving measurement and conversion of measurements. • CCSS.MATH.CONTENT.4.MD.A.1: Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. • CCSS.MATH.CONTENT.4.MD.A.2: Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. Represent and interpret data. • CCSS.MATH.CONTENT.4.MD.B.4: Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Solve problems involving addition and subtraction of fractions by using information presented in line plots.
ELP Standards	Receptive modalities • ELP 1: Construct meaning from oral presentations and literary and informational text through grade-appropriate listening, reading, and viewing. • ELP 8: Determine the meaning of words and phrases in oral presentations and literary and informational text. Productive modalities • ELP 3: Speak and write about grade-appropriate complex literary and informational texts and topics. • ELP 4: Construct grade-appropriate oral and written claims and support them with reasoning and evidence. • ELP 7: Adapt language choices to purpose, task, and audience when speaking and writing. Interactive modalities • ELP 2: Participate in grade-appropriate oral and written exchanges of information, ideas, and analyses, responding to peer, audience, or reader comments and questions. • ELP 5: Conduct research and evaluate and communicate findings to answer questions or solve problems. • ELP 6: Analyze and critique the arguments of others orally and in writing. Linguistic structures of English • ELP 9: Create clear and coherent grade-appropriate speech and text. • ELP 10: Make accurate use of standard English to communicate in grade-appropriate speech and writing.

Investigation 14

Movement of Water: Why Can We See the Roots of Trees That Grow Near Rivers or Streams?



Introduction

Trees can be found all over the world. A tree is a plant with a trunk made of wood. The trunk of a tree supports branches that hold leaves above the ground. A tree also has roots. The roots of a tree anchor it to the ground. The roots also make it possible for the tree to collect water and nutrients from the soil around it. Your teacher will have you look at some pictures of trees. Keep track of what you observe when you look at these trees and what you are wondering about as you look at them in the boxes below.

Things I OBSERVED …	Things I WONDER about …

We usually cannot see the roots of trees because they are underground. However, some of the trees that you looked at have roots that you can see. These trees grow near a body of water such as a lake, river, or stream. Trees need water to survive, and the amount of water available at a particular location determines how many and what types of trees are found at that location.

The water found in lakes, rivers, and streams comes from rain and snow. The amount of rain or snow that falls in an area determines the size of the lakes, rivers, and streams in the area. When there is a lot of rain or snow, lakes, rivers, and streams will fill with water and grow bigger and deeper. When there is very little rain or snow, the lakes, rivers, and streams in the area will shrink in size and may even disappear. Water moving in a river or stream can also break rocks and soils into smaller pieces and move the smaller pieces from one place to another. Water can therefore change the appearance of the land in a region.

In this investigation, your goal is to figure out why we often see the roots of trees that are found growing near a river or stream. You will need to create a physical model of a river with trees along it for this investigation. Your teacher will show you how to create your model using a stream table, sand, some pipe cleaners, and water. You can then use your physical model to test out your different ideas about what you think happens to the trees that grow near rivers and streams.

Things we KNOW from what we read …	What we will NEED to figure out …

Your Task

Use what you know about the movement of water over land, how water can move things around, and cause-and-effect relationships to design and carry out an investigation to determine how the movement of water in a river or stream (a *cause*) affects the soil around a tree (an *effect*).

The *guiding question* of this investigation is, ***Why can we see the roots of trees that grow near rivers or streams?***

Materials

You may use any of the following materials during your investigation:

- Safety glasses or goggles (required)
- Plant tray
- Small block of wood
- 10 pipe cleaners
- Funnel pitcher
- Rulers
- Stopwatch
- 1 cm grid transparency
- Wet-erase markers
- Water
- Sand

Safety Rules

Follow all normal safety rules. In addition, be sure to follow these rules:

- Wear sanitized safety glasses or goggles during setup, investigation activity, and cleanup.
- Do not throw pipe cleaners or sand, and do not put these materials in your mouth.
- Immediately clean up any spills to avoid a slip or fall hazard.
- Wash your hands with soap and water when you are done collecting the data.

Plan Your Investigation

Prepare a plan for your investigation by filling out the chart that follows; this plan is called an *investigation proposal*. Before you start developing your plan, be sure to discuss the following questions with the other members of your group:

- What might **cause** the appearance of the trees near rivers or streams to **change**?
- How can we **measure a change** over time?

Our guiding question:

This is a picture of how we will set up the equipment:

We will collect the following data:

These are the steps we will follow to collect data:

I approve of this investigation proposal.

Teacher's signature

Date

Collect Your Data

Keep a record of what you measure or observe during your investigation in the space below.

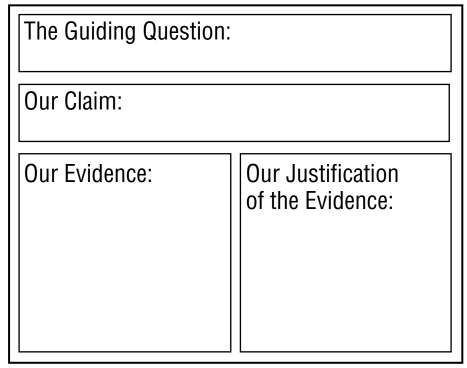
Analyze Your Data

You will need to analyze the data you collected before you can develop an answer to the guiding question. To do this, create a graph that shows the relationship between the cause and the effect.

Draft Argument

Develop an argument on a whiteboard. It should include the following:

- A *claim*: Your answer to the guiding question.
- *Evidence*: An analysis of the data and an explanation of what the analysis means.
- A *justification of the evidence*: Why your group thinks the evidence is important.



Argumentation Session

Share your argument with your classmates. Be sure to ask them how to make your draft argument better. Keep track of their suggestions in the space below.

Ways to IMPROVE our argument …

Draft Report

Prepare an *investigation report* to share what you have learned. Use the information in this handout and your group's final argument to write a *draft* of your investigation report.

Introduction

We have been studying ____ in class. Before we started this investigation, we explored ____

____

____

We noticed ____

____

____

My goal for this investigation was to figure out ______________________________________

____

____

The guiding question was ____

____

____

____

Method

To gather the data I needed to answer this question, I ______________________________________

____

____

____

____

I then analyzed the data I collected by

Argument

My claim is

The graph below shows

This analysis of the data I collected suggests ____

____

____

____

____

This evidence is important because of several scientific concepts. The first one is ______________

____

____

____

____

____

____

____

____

Review

Your friends need your help! Review the draft of their investigation reports and give them ideas about how to improve. Use the *peer-review guide* when doing your review.

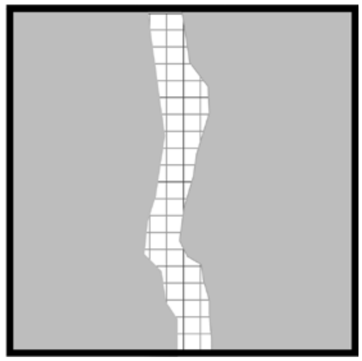
Submit Your Final Report

Once you have received feedback from your friends about your draft report, create your final investigation report and hand it in to your teacher.

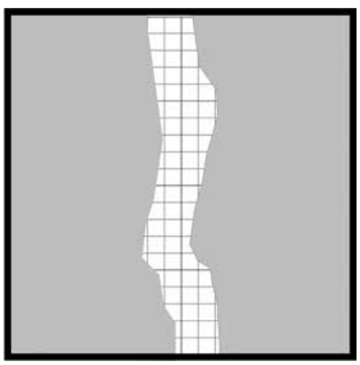
Checkout Questions

Investigation 14. Movement of Water

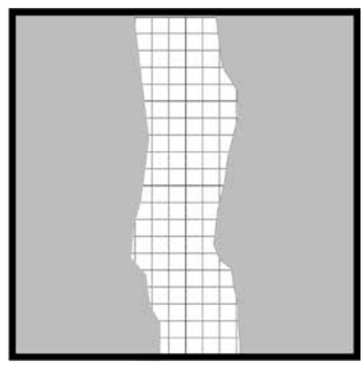
The picture below shows a creek and the land around the creek. The squares in the creek are 30 cm on each side. Use this information to answer questions 1–3.



1. Which picture below (A or B) shows the least amount of soil erosion along the banks of this creek? Circle your choice.

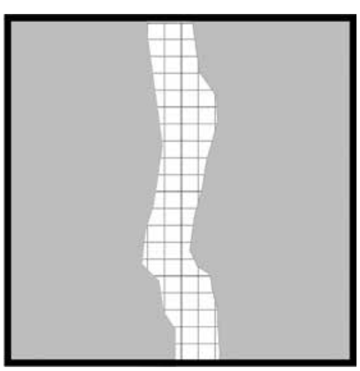


A

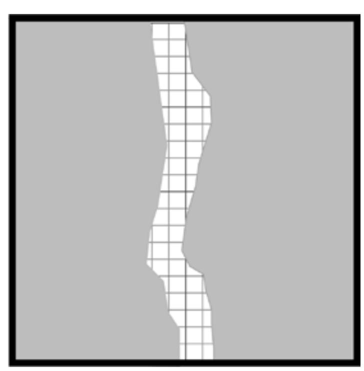


B

2. Which picture below (A or B) shows what the creek would look like after several days of heavy rain? Circle your choice.



A



B

3. Explain your thinking. What *cause-and-effect relationship* from your investigation did you use to answer these questions?

Teacher Scoring Rubric for the Checkout Questions

Level	Description
3	The student can apply the core idea correctly in all cases and can fully explain the cause-and-effect relationship.
2	The student can apply the core idea correctly in all cases but cannot fully explain the cause-and-effect relationship.
1	The student cannot apply the core idea correctly in all cases but can fully explain the cause-and-effect relationship.
0	The student cannot apply the core idea correctly in all cases and cannot explain the cause-and-effect relationship.

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Investigation 5

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Investigation 6

Figure 6.3: Ludovic Hirlimann, Wikimedia Commons, CC BY-SA 2.0, *https://commons.wikimedia.org/wiki/File:Electric_car_charging_Amsterdam.jpg*

Investigation 8

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Figure 8.6: Modified from crh23, Wikimedia Commons, CC BY-SA 4.0, *https://commons.wikimedia.org/wiki/File:Amplified_sine_wave.svg*

Investigation 9

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Investigation 10

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Investigation 11

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Investigation 12

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Investigation 14

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Investigation 15

Figure 15.1: Modified nautical chart from *http://fishing-app.gpsnauticalcharts.com/i-boating-fishing-web-app/fishing-marine-charts-navigation.html#11/-35.5350/173.3450*

Figure 15.2: Modified nautical chart from *http://fishing-app.gpsnauticalcharts.com/i-boating-fishing-web-app/fishing-marine-charts-navigation.html#12/-36.7900/175.4500*

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Argument-Driven Inquiry in Fourth-Grade Science

Three-Dimensional Investigations

Are you interested in using argument-driven inquiry (ADI) for elementary instruction but just aren't sure how to do it? You aren't alone. *Argument-Driven Inquiry in Fourth-Grade Science* will provide you with both the information and instructional materials you need to start using this method right away. The book is a one-stop source of expertise, advice, and investigations. It's designed to help your fourth graders work the way scientists do while integrating literacy and math at the same time.

Argument-Driven Inquiry in Fourth-Grade Science is divided into two basic parts:

1. **An introduction to the stages of ADI**—from question identification, data analysis, and argument development to evaluating and revising ideas.
2. **A well-organized series of 15 field-tested investigations** designed to be much more authentic for instruction than traditional activities. The investigations cover energy, waves and their application in technologies for information transfer, molecules and organisms, and Earth's place in the universe and systems. Using the *Student Workbook,* your students will explore important content and discover scientific practices. They can investigate questions such as these: How does the energy of a moving object change after a collision? How can you make an electric car move faster? And why do big waves block the entrance to some New Zealand harbors?

This book is part of NSTA's best-selling series about ADI in middle school and high school science. Like its predecessors, this collection is designed to be easy to use, with teacher notes, investigation handouts, and checkout questions. The lessons also support the *Next Generation Science Standards* and the *Common Core State Standards* for English language arts and mathematics. The book can also help emerging bilingual students meet the *English Language Proficiency Standards.*

Many of today's elementary school teachers—like you—want new ways to engage students in scientific practices and help students learn more from classroom activities. *Argument-Driven Inquiry in Fourth-Grade Science* does all of this while giving students the chance to practice reading, writing, speaking, and using mathematics in the context of science.

GRADE 4

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