Investigation 1
Soil and Water

Authors
Nancy Karre, Patti Smith, Dorothy Horan, Pat Traxler, Theron Blakeslee

Subject
Earth Science

Grade Level
4th grade or 1st semester of 5th grade

Driving Question
How do different earth materials interact with water?

Abstract
After messing about with water and three earth materials, student groups generate a researchable question about earth materials and water. They then design an investigation to answer their question, and carry it out.

Michigan Curriculum Framework Science Benchmarks
http://www.miclimb.net/content/main.html

Constructing New Scientific Knowledge Benchmarks:
I.1.E.1 Generate questions about the world based on observation.
Key concepts: Questions lead to action, including careful observation and testing; questions often begin with, "What happens if…?" or "How do these two things differ?"
Real-world contexts: Any in the sections on Using Scientific Knowledge.

I.1.E.2 Develop solutions to problems through reasoning, observations, and investigations.
Key concepts: Observe, predict, collect data, draw conclusions, conduct fair tests; prior knowledge.
Real-world contexts: Any in the sections on Using Scientific Knowledge.

I.1.E.3 Manipulate simple devices that aid in observation and data collection.
Tools: Various data collection tools suitable for this level, such as hand lenses, etc.
Real-world contexts: Any suggested in Using Scientific Knowledge benchmarks for which students would design and/or conduct investigations.

I.1.E.4 Use simple measurement devices to make measurements and investigations.
Key concepts: Measurement units—milliliters, liters, teaspoons, tablespoon, ounce, cup, millimeter, centimeter, meter, gram.
Real-world contexts: Making simple mixtures, such as food, play dough, papier mache; measuring height of a person, weight of a ball.

Reflecting on Scientific Knowledge Benchmarks:
II.1.E.1 Develop an awareness of the need for evidence in making decisions scientifically.
Key concepts: data, evidence, sample, fact, opinion.
Real-world contexts: Deciding whether an explanation is supported by evidence in simple experiments, or relies on personal opinion.

Using Earth Science Knowledge Benchmarks:
Geosphere V.1.E.2 Recognize and describe different types of earth materials.
Key concepts: Materials—mineral, rock, boulder, gravel, sand, clay, soil.
Tools: Hand lens.
Real-world contexts: Samples of natural earth materials, such as rocks, sand, soil, ores.

Hydrosphere V.2.E.2 Trace the path that rain water follows after it falls.
Key concepts: Precipitation—see V.3.E.1. Flow—downhill, to rivers, into the ground.. Bodies of water—streams, rivers, lakes, oceans. See V.1.E.1 (earth features).
Real-world contexts: Examples of water flowing locally, including gutters, drains, streams, wetlands.

Big Ideas
1) Earth materials can be described and distinguished from one another by the size of their particles and the ways they interact with water. 2) Some of the rain that falls on the Earth flows downhill off the land into streams and rivers, and some of it soaks into the ground. 3) The water that soaks into the ground can be used by pumping it back up to the surface, in wells (see V.2.E.3, Sources and Uses of Water).

Prerequisites for Students
None

Estimated Time Needed
Five class periods of approximately 55 minutes each.

Background Information
Glaciers covered Michigan and finally melted ten to fourteen thousand years ago. As the ice melted, the earth materials held by the glaciers ended up on the earth's surface and now make up the surface of the land in most places in Michigan. Our land is made up primarily of sand, gravel, clay and silt, all left by the glaciers. There are also some bedrock outcroppings in Michigan, especially in the Upper Peninsula – places where the solid rock that underlies the soil is exposed above the ground.

Pieces of bedrock and other rock formations make up the smaller rocks we call gravel. When gravel or bedrock is broken up further, the tiny pieces are called sand. Clay is an earth material made of many very small, pancake-shaped particles. Clay particles are so tiny that they cannot be seen, even through hand lenses.

Soil is a combination of these materials with decayed organic matter – dead plants and animals that have broken into small pieces and are at various stages of decomposition. This organic matter in soil is called humus. Humus is the component of soil that is black or brown. The color of a sample of soil depends on how much sand and/or clay is mixed in with the humus.

What determines how well water flows through earth materials is their permeability. Permeability is the measure of how well-connected the pores (empty spaces) between the pieces of earth material are. If water cannot flow easily from one pore space to another, the earth material is not very permeable. Water does not flow easily through less permeable materials (such as clay). Students need not be familiar with the term, permeability. However, they can view pores between pieces of earth materials with hand lenses (except the pores in clay, which are too small).

When students look at a cup of gravel, they can clearly see how well-connected and how large the pore spaces are. Gravel has a high permeability, and groundwater moves quickly and easily through gravel (from one pore space to another). Sand’s interconnected pores can been seen when viewed through a hand lens, too, though they are not as easy to see as gravel’s. Students can experience sand’s high rate of permeability when they pour water through it. Bubbles that form on the surface of wet sand are evidence of the air that was previously in the pore spaces between sand particles. Air is displaced as water enters those pores. Lots of groundwater can fit in the pores between sand particles, the pores between pieces of gravel, and the pores between particles of mixed sand and gravel.

Clay is an earth material harder to understand. Students cannot see tiny clay particles with their hand lenses. The pancake-shaped particles stack up to form a less permeable material. An illustration of this can be made by ripping magazine pages into quarter-sized pieces. Lay these flat in a cup with holes poked in the bottom. If water is poured through, the poorly-connected pore spaces will slow its movement almost completely (but not totally—water can make it through any natural surface over time). Clay particles also do absorb some water, causing them to swell. This is not true of sand and gravel. Water is hard to extract from clay. (Wet clay is the form that is most often handled by students in art class.)

Because water moves through these different earth materials at different rates, and because Michigan soil varies from one place to another in its composition, groundwater flow varies tremendously from location to location in Michigan. Groundwater flow is also affected by the amount of water present.

The Michigan benchmark for elementary asks students to recognize the differences between types of Earth materials. They do not need to learn a complete explanation of where the different Earth materials come from – that is a middle school benchmark. They also do not need to learn a complete explanation of ground water – again, middle school. But they do need to recognize that significant amounts of rain soak into the ground, and that we get a large amount of our drinking water from wells that pump water out of the ground.

This lesson gives each student group a chance to design and do an investigation. Student groups answering different questions related to earth materials and water can all use the format given to develop and test their hypotheses in a scientific manner. However, not every question is one that should or can be investigated experimentally. Part of the role of the teacher in this lesson is to recognize this, and to encourage students to develop questions that can be answered through investigation. To determine whether a student question is worthy of scientific investigation, check the following criteria:

- Does the question involve how something changes when acted on by something else?
- Does finding the answer involve some scientific process?
- Is the process something that can be demonstrated in the classroom or on school grounds?
- Does finding the answer involve some comparison?
- Is the answer something that can be measured?

Some questions, such as, “What type of earth materials are in each region of Michigan?” cannot be answered by scientific investigation by an elementary school student. However, it is a worthy question that could be answered through research in the library or on the Internet.

Teacher Page 1-1 gives a sample of how a student group might fill out Student Page 1-2, involving investigation design. Teacher Page 1-2 is an example of a Research Methods page, which students will use to record the step-by-step details of their investigation. Teacher Page 1-3 gives an example of a group’s Conclusion (Student Page 1-3). These are meant to be used as examples, not as instructions for any group’s investigation.

Materials List

For Each Student

Hand lens
Plastic spoon

For each student group

Aluminum pie pan
Newspaper for covering table (these materials can be messy)
1 Jug of water
1 Dropper
4 Plastic cups with 8 holes punched in the bottom (from the inside out)
4 Coffee filters
Bowls or pans
Ruler
1 copy of Student Pages 1-1, 1-2, and 1-3 (have extra copies of 1-2 on hand)

For the class

Dry sand
Dry clay (Crushed kitty litter works well. Get the cheapest kind of kitty litter, put in a heavy plastic bag, and crush with a hammer. Dry potter’s clay is also acceptable, if your art teacher or the art department at your high school has some.)
Gravel (washed aquarium gravel works well)
Humus (dry potting soil)
Soil dug from somewhere around school yard, and allowed to dry for a week or so indoors
Paper towels or rags (to wipe up spills)

Procedure

Part 1: Student Exploration (Day 1)

1. Break students into small groups. Place newspaper over each desk where students will be working. Distribute a sample of dry soil to each group on a pie pan, along with a hand lens and plastic spoon for each student. Ask students to gently pull apart the soil sample into smaller pieces, and observe each clump with their hand lens.

2. Hand out Student Page 1-1, "Earth Materials Observations." Ask the students to use their observation skills and record data about the attributes of the earth materials, using descriptive language. (If you prefer, your students can create a data collection page themselves instead of using this Student Page. They will need to consider what types of observations they plan on making, and the total number of earth materials they will observe.)

3. Ask students to share their observations with the whole class. If students don't volunteer this, ask them whether they think soil is made up of only one kind of material or several different kinds. Help them describe the components of soil in terms of color, texture, size of particles, etc. If they have names for different particles within the soil, let them use those names, but also ask them to describe each thing they see.

4. Ask students to generate questions about the soil they observed. Write their questions on the board for later use.

5. Distribute samples of earth materials (sand, gravel, clay and humus) on a pie pan to each group. Ask the students to identify the samples and observe each sample in the same way they observed the soil. Have them discuss in their groups what they see, then write their observations on their observation page.

6. Facilitate the students' early observations by listening to these small group discussions. If students continue to generate questions about these Earth materials while they are observing, encourage them to record their questions on their observation page.

7. Facilitate student observations by asking what similarities and differences they are noticing in the earth materials. Ask them whether they think they observed any of these Earth materials in their sample of soil.

8. Once the students have become involved in their observations, tell them you will distribute a cup of water and dropper to each group. Tell them to use drops of water as they see appropriate to enhance their observations. They should record any new observations (about the ways that water interacts with the materials).

   You can put these observations with water into context: When rain falls on the land, some of it gathers into little streams that flow into bigger rivers and lakes. Some of the rain also soaks into the ground. How does the amount of sand or pebbles or clay or humus in the soil change the amount of rain water that can soak into the ground?

9. Ask the groups to begin to record questions they may have regarding how the water interacts with the Earth material.

10. Have each group share some of their observations about water and earth materials with the class. Focus the discussion on the interaction with the water. Draw their attention to "standing water" or "pooling water" compared with "absorbed water" or "filtered water." Allow the students to generate additional questions based on the class sharing. Make a list of these questions.

Part 2: Questions to Investigate

1. Add students' questions about water and Earth materials to the list they generated about soil. Questions may include:
   - Which earth material holds the most water?
   - Which earth material lets water pass through most easily?
   - Will plants grow the same in all the earth materials?
   - Why does the water stay on top of the silt and clay?
   - Where do you find clay and silt?

   Some of these questions are easier to answer by conducting investigations than others. The fourth question in the list isn't worded in a way that it can be investigated easily. Most "why" questions are hard to investigate. Students need to change "why" questions into "how much" or "how long" questions, such as "How long does water stay on top of clay?" Later, after they have gathered data to answer their question, they can think about *why* things work they way they do. Those are important questions, but they need to collect data first.

   Also, the last question in the list can be answered by searching through the library or on the Internet, but does not require students to design and conduct an investigation where they manipulate materials and collect data. Again, these are important kinds of questions that can be supplemental to this investigation.

2. Ask students to look at the questions having to do with how water and Earth materials act together. Ask each group to choose a question from this shorter list that is of interest to them – a question that will require them to collect data. If students need to change groups to follow a topic of interest, now is the time to do so.

   The questions will usually be about **how long it takes water to pass through the different substances** (e.g. Which material allows water to flow through it mostly quickly?) or about **how water is absorbed by each material** (e.g. Which material holds the most water, and which allows the most water to pass through?) Other questions are possible, depending on the ideas generated by the students. The methods described below are for the two questions listed here, but if you and the students can design suitable methods for gathering data for other questions, then they should be allowed to investigate those questions.

Part 3: Method for Gathering Data

1. After groups determine which question they want to investigate, they need to develop a method for collecting their data. After their initial exploration and question-setting, they may have some good ideas on how to proceed to collect data in support of their question. Also, the two investigations envisioned here – how long it takes for water to go through various Earth materials, or how much water each type absorbs, do not require sophisticated methods, but they do require carefully laying out the details of the method.

   The first step in developing a method that will allow students to gather data is to put on paper the ideas that everyone in the group has already. This is best done through the process of brainstorming. You may have to explain brainstorming to the students: Brainstorming is an idea-generating process. There are no right or wrong answers. One person in the group writes down all the ideas that people have. It is OK to "piggyback," or develop someone else's idea. They do not all have to be original ideas. Repeating ideas is OK, too.

2. Hand out a piece of newsprint and a marker to each group and let them brainstorm for 5 or more minutes.

   Some possible ideas students may come up with in the brainstorm include:
   - Fill a cup with layers and watch to see where water moves fastest.
   - Pour water on piles and see which goes to the bottom fastest.
   - Have a cup of each earth material and pour water on them and then poke a hole in the bottom and see which leaks out fastest.
   - Use cups with holes in the bottom to see which one water comes out of fastest.
   - Fill a pie pan with each earth material and see which one sucks up the water.
   - Look at each earth material with a hand lens and see if we can tell which one water will move through fastest.

3. After brainstorming slows down, have each group look carefully at their brainstormed methods, to find the one they think will work the best to collect data to answer their question. They need to find a method that results in numbers that can be used to compare each Earth material – that is, they need times or amounts of water, not just "this looks like the fastest…"

4. Give groups 5 more minutes to discuss and decide on the group's preferred method. If students want to do library/Internet research to answer the question, tell them they need to design an investigation right now. They can do the other research later in the process, as a check on their own experiment.

5. Circulate among the groups and discuss each method. Help them figure out how to make accurate measurements with their method. A sample method is shown on Teacher Page 1-1: Investigation Design Sample Student Responses.

6. Have each group fill out Student Page 1-2, Investigation Design. They will add their prediction at the next step. Work with each group to help them complete these pages accurately and adequately.

Part 4: Prediction

1. Once each group knows how it will conduct its experiment, have them predict what the outcome of the experiment will be. For example, if they are conducting an experiment to see which type of material absorbs the most water, their prediction should be something like: If we pour the same amount of water on each of the four types of materials, the humus should hold on to the most amount of water, so that less water will drip through the humus than the other types. (Actually, this isn't true, but some groups may predict this. More water is absorbed by the clay.)

2. Have each group record its prediction on their Investigation Design page.

Part 5: Research Details

1. Using a page titled "Research Methods," have students write a detailed plan for conducting their investigation. The plan should list every step they intend to take. They should also include a data collection chart. (A sample Research Methods page and data table, is shown as Teacher Page 1-2.)

2. Have groups hand in their Research Methods and Investigation Design pages. Review them, looking for things like equipment availability, if there is time to do their research, if it is doable by students this age, and general workability. Check each group's design to make sure it will result in measurable data that may support or not support the hypothesis. Give guidance as you review the materials, but try not to dictate specific changes. This is best done by asking critical questions such as, "How will you measure that?," and "What things will you keep the same?" Then groups can come up with changes that answer your questions and critiques.

3. **(Day 2)** Return the Research Methods with your comments and let groups re-design or alter their research methods as needed. Each student should write down her or his own copy of the final investigation design. Make sure each group saves the original Student Page, and changes their answers on it to reflect any changes in investigation design. You may want to have extra copies of this Student Page available, for those groups whose design has changed a lot.

   Many times the observations and results of an open inquiry activity drive the next step in an investigation. Tell students that this is OK. If student groups add steps or change things as they perform their investigation, they should write these down, too.

Part 6: Data Collection

1. Let each student group perform their investigation as they have written it. If they make changes as they go, they should reflect this on their written methods. They should record their results on their data collection page.

Part 7: Data Analysis, Use and Communication of Results

1. Have each group share its data table with the class. Discuss similarities and possible discrepancies between groups that have conducted the same investigation. Ask whether the different research groups support each others' conclusions.

   Have each group look at its results and determine what they show. Help each group determine whether the data supports its prediction, and what the answer would be to their initial question.

2. **(Day 3)** Ask students if a graphic representation of their data (a bar graph, a line graph, a pie chart or a labeled diagram) might help them and others better interpret their results. For example, could they tell from a graph of their data what Earth material allowed water to pass through the fastest?

   Have each group develop a graphic representation of its data to communicate the results. Teacher Page 1-2b can be made into an overhead transparency to help the whole class make appropriate bar graphs, if needed. An alternative would be to have any groups that are capable use a computer spreadsheet (such as Excel) to input their data and produce a chart/graph.

3. Give each group Student Page 1-3, Thinking About the Data. Have each group discuss each question. The questions are designed to help students *use* the information they gathered through the investigation to go deeper into the concepts behind the phenomena they studied. After the small group discussions, ask each group to report out their ideas and discuss within the whole class.

4. Write the following parts of a conclusion on the board, and as you write each one, ask one student from one of the various groups to answer it. This will help clarify what is being asked for:
   - What was the purpose of the investigation?
   - What did you find out?
   - Was the prediction supported by the data?
   - How does what you found out compare with what other researchers have found out? (There should be some consistency of findings among the groups within the class, even if they did slightly different experiments.)
   - How can you explain what you found out? (Explanations should mirror the answers to questions from step 3 above.)
   - Why was it important to keep certain things the same during the different trials? (If different amounts of water or different amounts of materials were used, or if different criteria were used for judging when water stopped flowing, for example, then the students did not conduct a "fair test," and the results would not be reliable.
   - What else would you like to do with this investigation, and how would you make it better?

5. After the class discussion, have each individual student write a conclusion about their own investigation that incorporates answers to each question, using Student Page 1-4.

6. **(Day 4)** Have each group present its question, prediction, research methods, graphic representation of data, and conclusion to the class. Every group member should have a part in the presentation. Presentations should include these parts (write them on the board):
   - The group's question
   - The full prediction
   - The research methods
   - The data, presented as graphs, charts, or drawings
   - The conclusion
   - Participation by each group member

   If most or all of the groups conduct the same investigation, you might draw straws to see which group will present their investigation. Multiple presentations of the same investigation can become boring. You might ask one or more of the groups to make presentations of their investigations at other times, such as parent nights or school board meetings, or they can make posters that present their investigations and display them in the school.

7. Have students turn in all Student Pages, the Research Methods, and the Data Collection pages for assessment purposes.

Part 8: Guided Questions for Reflection

1. The following questions may be asked of each group:
   - Did your data support your prediction?
   - What conclusions did you draw from your data?
   - What did you find out about how earth materials interact with water?
   - Were there any problems with the design of your investigation? (Did things you did not expect or did not plan for happen?)
   - How could your investigation design be improved?
   - What does your investigation tell us about how water flows above ground (surface water)?
   - What does your investigation tell us about how water flows underground (groundwater)?

2. These questions can be asked of the class:
   - How are earth materials different from each other?
   - What is the path of rain water after it hits the ground?
   - What affects how water moves underground?
   - How are groundwater and surface water connected?
   - What happens if a pollutant is introduced into surface water?
   - What happens if a pollutant is introduced into groundwater?
   - Who drinks groundwater? (Half the population of Michigan, and of the United States. Anyone with a private well or a municipal well.)

Part 9: Student Questions for Additional Inquiry

1. Ask the class:
- Are there questions the investigations didn't answer? What are they?
- How could these questions be answered?

2. If you are able, do some of these subsequent investigations with students.

Assessment

Group assessment can be made by ranking proficiency in each of the parts of the final presentation: the prediction, the Investigation Design page, the step-by-step Research Methods, the graphic presentation of the data collected, the conclusion, and, finally, the participation of all members. Student Pages 1-2 and 1-3 can be assessed as well.

Individual assessments can be done by interviewing individual students about their group's project and assessing their understanding of what the group did and why it was done. If desired, you may require each student fill out their own copy of the Student Pages.

Student Page 1-1

Name ____________________________

Earth Materials Observations

Soil: ____

____

____

____

____

____

Earth Materials

Type __________

____

____

____

____

Type __________

____

____

____

____

Type __________

____

____

____

____

Student Page 1-2

Names ______________________________

Investigation Design

1. What is our question?

2. What do we know? – about how water flows through Earth materials

3. What will we do? – to figure out how fast water moves through Earth materials

4. What data will we collect?

Student Page 1-2 con't

5. What is our prediction?

6. The things we keep the same on purpose are:

Name______________________________

Thinking About the Data

Answer all of these questions in your conclusion:

1. How are Earth materials different from each other?

____

____

____

____

____

2. What happens to rain water after it hits the ground?

____

____

3. Why does water move faster through some kinds of Earth materials than through other kinds?

____

____

____

____

____

4. Why does rain water puddle up on some areas of the ground more than on other areas?

____

____

____

____

____

Names____

Conclusion

Answer all of these questions in your conclusion:

1. What was the purpose of the investigation?
2. What did you find out?
3. Was the prediction supported by the data?
4. How does what you found out compare with what other researchers have found out?
5. How can you explain what you found out?
6. Why was it important to keep certain things the same during the different trials?
7. What else would you like to do with this investigation, and how would you make it better?

Teacher Page 1-1

Names (Sample student responses)

Investigation Design

1. What is our question?
   How long does it take for water to go through different Earth materials.

2. What do we know? – about how water flows through Earth materials
   Water flows very quickly through pebbles.

3. What will we do? – to figure out how fast water moves through Earth materials
   We will pour the same amount of water through similar size samples of different Earth materials, and let the water run through. We will time how long it takes through each type of material.

4. What data will we collect?
   We will keep track of how long it takes, in seconds, for water to flow through each sample.

5. What is our prediction?
   Water will go through pebbles and sand faster than humus or clay.

6. The things we will keep the same on purpose are:
   We will use the same amounts of water and each Earth material. We will time the water flow until the water completely stops dripping.

Teacher Page 1-2

Names (Sample student responses)

Research Methods

1. Use 4 plastic cups with holes in the bottom.
2. Put a coffee filter in each one so the Earth material doesn't fall through the holes.
3. Fill each one with 50 ml of sand, gravel, humus and clay.
4. Add 40 ml of water to each, one at a time.
5. Use the second hand of the clock to time how long it takes for the water in each cup to stop flowing.
6. Repeat the trials with each sample, and record the time it take for water to pass through each sample when it is already wet.

A sample data collection chart and graph for communicating results is shown on the next page. You could make the next page into an overhead transparency if you want to work with the whole class on making bar graphs. Alternatively, students could put their data into a computer spreadsheet (like Excel) and generate a graph or chart.

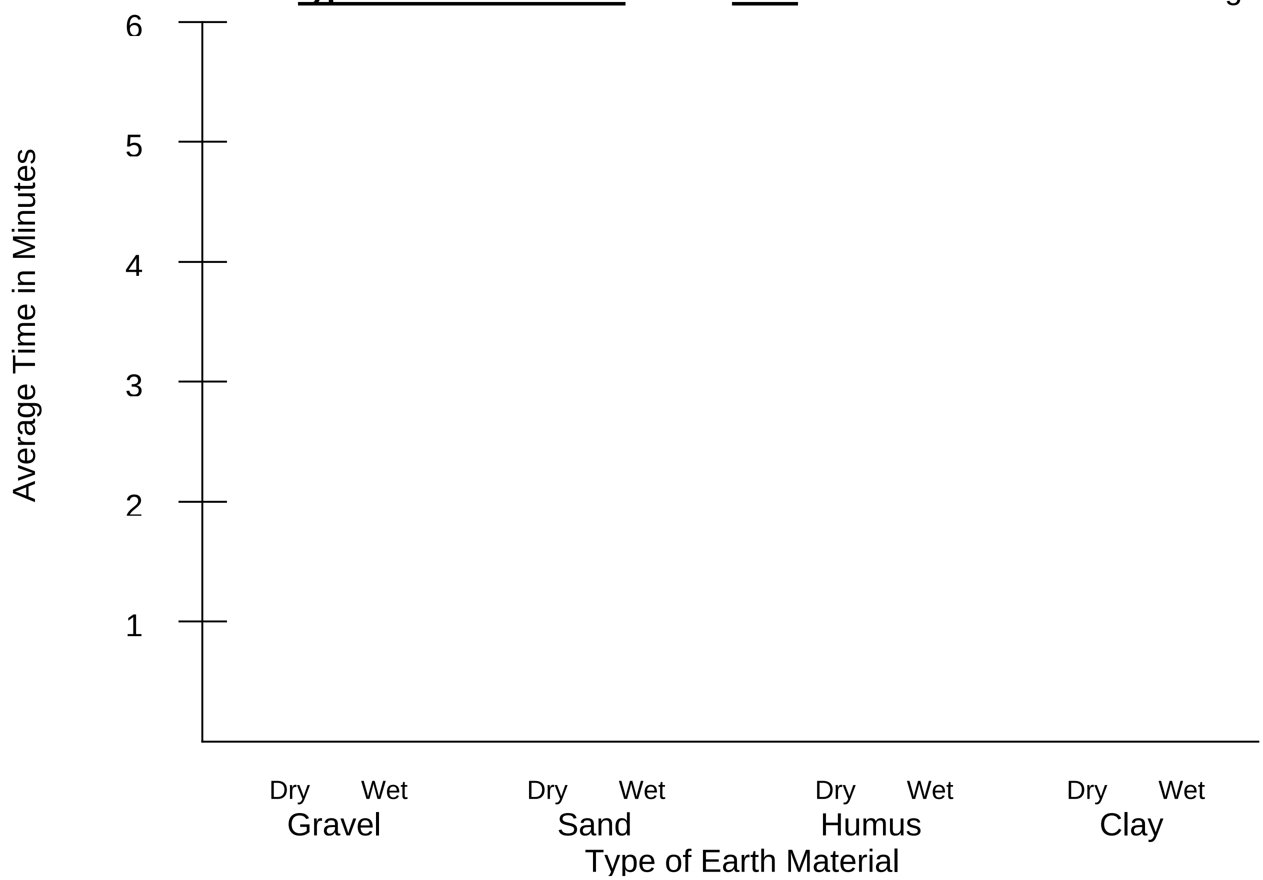
Teacher Page 1-2, con't

The effect of the **type of Earth material** on the **time** it takes for water to flow through it.

Type of Earth Material	Time it takes for water to flow through it	
Medium	Dry (first trial)	Wet (second trial)
Gravel		
Sand		
Humus		
Clay		

Observations:

Bar Graph:
The effect of the **type of Earth material** on the **time** it takes for water to flow through it.



Names____

Conclusion

Answer these questions in your conclusion:

1. What was the purpose of the investigation?
2. What did you find out?
3. Was the prediction supported by the data?
4. How does what you found out compare with what other researchers have found out?
5. How can you explain what you found out?
6. Why was it important to keep certain things the same during the different trials?
7. What else would you like to do with this investigation, and how would you make it better?

We did this investigation to find out how fast water moves through four different earth materials. We found out that water moves quickest through gravel, next quickest through sand, more slowly through humus and most slowly through clay. Our prediction was: Water will go through pebbles and sand faster than humus or clay. Our prediction was supported, although we learned more than what we predicted because our prediction was not clear enough.

Other researchers in our class found the same thing. We think that the reason water moves so quickly through the gravel is the big open spaces between the little rocks let the water get through really fast. The open spaces between pieces of sand are way smaller. We can’t even see the spaces between pieces of clay once it gets wet.

It was important to use the same amounts of different materials and the same amounts of water so that we had fair tests. We could only compare the times if we used the same amounts of each.

We would like to try this investigation with mixtures of earth materials. We think it would work better with bigger cups.