**5E Lesson 2: Fossil Footprints- Science**

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| **Content Area: Earth Sci.** | **Grade Level(s): 9+** | **Topic(s): Nature of Science** |

**Standards (SOL)**

Earth Science SOL Standard

ES.1c,e

ES.2a,b,c,d

**Objectives (UKD’s)**

Students should be able to:

1. Differentiate between terms ‘fact’ and ‘inference’
2. propose explanations and make predictions based on evidence,
3. recognize and analyze alternative explanations and predictions,
4. understand that scientific explanations are subject to change as new evidence becomes available,
5. understand that scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

**Materials & Resources**

1. A large fossil print (or skeleton) in the room to spark inquiry of lesson
2. Footprints PowerPoint (contains student sheet to record facts –slide # 2 & the three individual slides, inferences, and sketches–slide #s 3,4,5 )
3. Print copies of 2-sided record sheet for each student

\*A response key is provided on slide #6

*Teaching About Evolution and the Nature of Science*. (1998). Washington, DC:

 National Academy Press. 87-89

**Safety Considerations**

If a fossil is passed around the class, extra care should be taken to prevent an accidental drop or fossil breakage.

**Engage – Time Estimate 10 minutes**

1. Tell the students that they will be viewing a series of three slides (positions) of footprint tracks. A class discussion or think-pair-share can be used to list facts that they observe first, then inferences—possible hypothesis’. A record sheet is provided to log their data and add a general sketch.
2. Project position 1 of the footprints from the PowerPoint using slide #3. Tell the students that tracks like these are common in parts of New England and in the southwestern United States. Point out to the students that they will be attempting to reconstruct happenings from the geological past by analyzing a set of fossilized tracks. Their problem is similar to that of a detective. They are to form defensible explanations of past events from limited evidence. As more evidence becomes available, their hypotheses must be modified or abandoned. The only clues are the footprints themselves. Ask the students: Can you tell anything about the size or nature of the organisms? Were all the tracks made at the same time? How many animals were involved? Can you reconstruct a series of events represented by this set of fossil tracks?

(Have the students discuss each of the questions either in pairs or a class. Accept any reasonable explanations students offer. Try consistently to point out the difference between what they observe as fact and what they infer. Ask them to suggest evidence that would support their proposed explanations.)

**Explore – Time Estimate 10-15 minutes***.*

1. Reveal the second position of the puzzle from using slide #4 and allow time for the students to consider the new information. Students will see that the first explanation may need to be modified and new ones added. Remind students to gather the data for their chart focusing on the observable facts first. Then they can add or list inferences or hypothesis.
2. Next project the complete puzzle using slide #5 and ask students to interpret what happened. A key point for students to recognize is that any reasonable explanation must be based only on those proposed explanations that still apply when all of the puzzle is projected. Remind students to gather the data for their chart focusing on the observable facts first. Then they can add or list inferences or hypothesis. Any interpretation that is consistent with all the evidence is acceptable.

(Should it become necessary to challenge the students' thinking and stimulate the discussion, the following questions may help. Students should give evidence or suggest what they would look for as evidence to support their proposed explanations.)

* In what directions did the animals move?
* Did they change their speed and direction?
* What might have changed the footprint pattern?
* Was the land level or irregular?
* Was the soil moist or dry on the day these tracks were made?
* In what kind of rock were the prints made?
* Were the sediments coarse or fine where the tracks were made?
* Where the tracks made simultaneously by the animals?
1. The environment of the track area also should be discussed. If dinosaurs made the tracks, the climate probably was warm and humid. If students propose that some sort of obstruction prevented the animals from seeing each other, this might suggest vegetation. Or perhaps the widened pace might suggest a slope. Speculate on the condition of the surface at the time the footprints were made. What conditions were necessary for their preservation?

**Explain -- Time Estimate 10 minutes**

1. The student Fossil Footprints Record sheet was created so that students can log their observations of facts & inferences. Teachers can monitor discussions for misconceptions during think-pair share or general open class discussion. Encourage editing throughout the activity.
2. An imaginative student should be able to propose several possible explanations. One of the most common is that two animals met and fought. No real reason exists to assume that one animal attacked and ate the other. Ask students who propose this explanation to indicate the evidence. If they could visit the site, what evidence would they look for that would support their explanation. Certain lines of evidence—the quickened gaits, circular pattern, and disappearance of one set of tracks—could support the fight explanation. They might, however, support an explanation of a mother picking up her baby. The description and temperament of the animals involved are open to question. Indeed, we lack the evidence to say that the tracks were made at the same time. The intermingling shown in the middle section of the puzzle may be evidence that both tracks were made at one time, but it could be only a coincidence. Perhaps one animal passed by and left, and then the other arrived.
3. Discuss the expected learning outcomes related to scientific inquiry and the nature of science. To answer the questions posed by the set of fossil footprints, the students, like scientists, constructed reasonable explanations based solely on their logical interpretation of the available evidence. They recognized and analyzed alternative explanations by weighing the evidence and examining the logic to decide which explanations seemed most reasonable. Although there may have been several plausible explanations, they did not all have equal weight. In a manner similar to the way scientists work, students should be able to use scientific criteria to find, communicate, and defend the preferred explanation.

**Extend -- Time Estimate 10 minutes**

You can have more discussions on interpreting series of events using animal prints students find outdoors and reproduce for the class. Do not forget to look for human footprints. Have students design a different fossil footprint puzzle. Choose several different ones and have student teams repeat the activity using the same learning goals.

Slide #7 provides an opportunity to connect the activity to everyday life and occupations that may need to gather data to make inferences or hypothesis’.

**Evaluate -- Time Estimate 10 minutes**

Describe a specific event involving two or more people or animals where footprint evidence remains. Ask the students, either in teams or individually, to diagram footprint evidence that could lead to several different, yet defensible, explanations regarding what took place. They should be able to explain the strengths and weaknesses of each explanation using their footprint puzzle.

**Plans for Diversity**  *Student(s): Category/Characteristics: Accommodations:*

Students with colorblindness may be challenged with seeing the appropriate colors. Let them know that you’ll take that into consideration and focus on other observations instead.

Since all student inferences are acceptable, there is minimal threat of having a wrong answer.

Special needs students who require a copy of teacher’s notes should ‘attempt’ to fill-in the record chart; a copy of the key (slides # 6 & 8) can be provided.

**Connections**

--A great activity to ‘begin teaching science’ during the first couple days of school. Since all inferences could be correct, more students fell secure about participating in an open discussion. It would also reinforce a previous lesson taught about differentiation of ‘facts’ and ‘inferences’ and would make connections to their everyday lives. It ties into the VA SOLs—scientific investigation and is generally found early in the scope and sequence of the course.

If the teacher supports the notion that there are many possible outcomes to ‘reading the fossil prints’, then the Nature of Science can be interwoven through many future concepts of Earth Science. This especially occurs when observations are used to gather facts, and inferences are made to make predictions about the world around us. For instance, the ‘Big Bang’ & ‘Dinosaur Extinction’—we acquire evidence to support, but not prove those theories. The students can reflect back to the footprints activity and realize that assessing factual information provided was limited, yet they had a multitude of inferences made about what could have happened in the past. In nature, we don’t know unless we were witness to particular events. This activity fits in whenever students inquire during the year, “How do scientists know… for sure?”

The activity can also be used to show general scientific method steps or the experimental design process, sequencing activities, and relating it to real world daily occupations.

 It also can be used prior to an activity where students represent scientists and each is given a container with an ‘unknown’ prehistoric fossil. They are challenged to use this fossil, or piece of fossil, to draw/sketch the organism with its original environment/habitat.