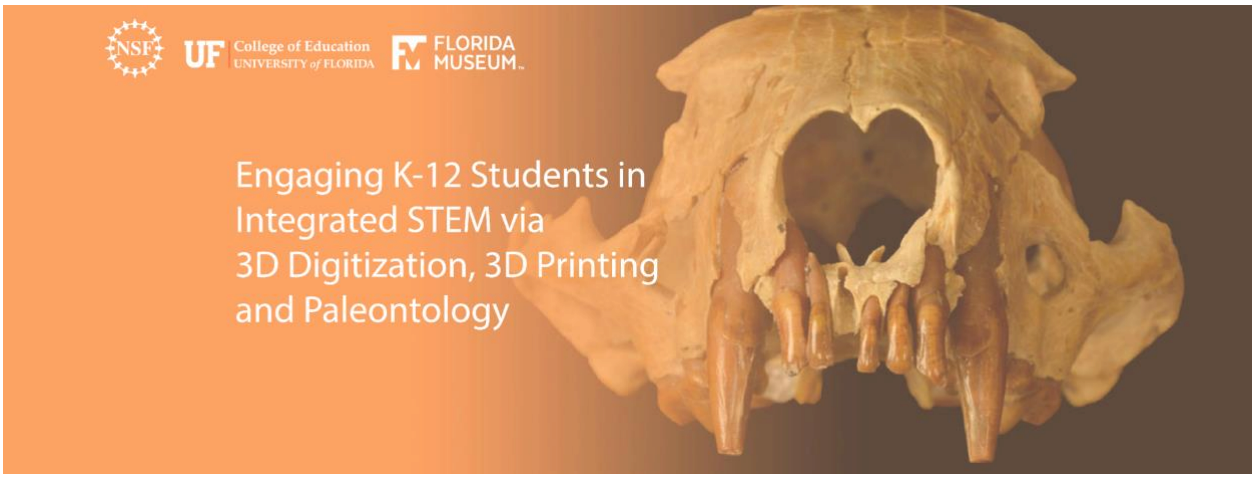

AUTHOR

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LESSON TITLE

How big was the Megalodon? (A modified lesson for elementary grades.) Credit to original lesson authored by Megan Hendrickson and Victor Perez.

GRADE LEVEL

4th grade

TIME FRAME

4-5 class periods of 45 minutes each

DRIVING QUESTION

If the megalodon is extinct and it did not leave skeletons behind, how do we really know how big it was or why it went extinct?

LEARNING GOALS

Learning goals for students are two-fold. First, by using 3D models of actual fossilized megalodon teeth students will mathematically figure out the length of "their shark". Second, after understanding the immense size of these animals and observing the massive teeth, students will investigate how such a predator could go extinct.

ANCHORING EVENT

Begin by showing students about 10-15 minutes from the following video on megalodons. Inform students that following the video they will be using actual printed models of megalodon teeth to help scientists figure out the size of the shark it came from.

https://www.youtube.com/watch?v=tkHIGBfpllA

COLLABORATIONS

Students should be placed in groups of 4-6 during the measurement and calculation of the meg tooth. The math in this lesson is difficult, and placing students in groups with at least one higher level math student would be helpful. These groups will also be useful later in the lessons when students are discussing their arguments regarding the extinction of the megalodon.

STEM INTEGRATION

Science: Students will be using fossilized megalodon teeth to investigate its size
Technology/ Engineering: Students will be using 3D printing to have "hands-on" access to the fossilized teeth
Mathematics: Mathematical computations using measurement, multiplication, order of operations and negative numbers are used in the calculation of the length of shark.

ASSESSMENT

Students will be assessed throughout the activity. Students will be expected to fill out their own packet of work (attached in the "handouts" section). Teachers can use this to check progress on each student's thinking and work. Observation assessment will also be used as students build their argument regarding extinction of the shark. A proficient student will need to use evidence gathered from videos or articles to back-up their thinking during the summative essay.

PROCEDURE

Prepare student handouts (located at the end of lesson). Place students into groups of 4-6. Gather materials for each group (caliper, pencils, calculators).
Teach students ahead of time how to use a caliper and how to take 3 point measurements. (see below)

How to take 3 point measurements:
The first step is to turn the tooth into a triangle by marking three points on a sheet of paper: A) where the crown meets the left root lobe, B) where the crown meets the right root lobe, and C) the tip of the crown (see image below).

2. Now measure a perpendicular line from the crown tip (C) to the line segment AB. This is your crown height, or X in your equation. Remember to measure the CH in millimeters.

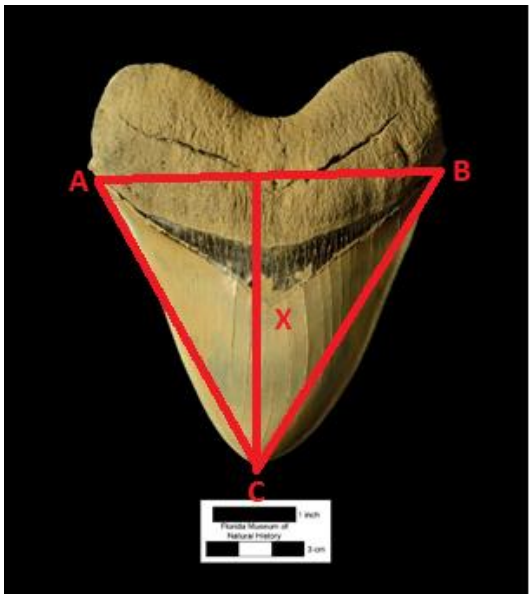
Day 1: How Big was the Megalodon?
Engage: Begin lesson with a 10 minute clip of the following video:
https://www.youtube.com/watch?v=tkHIGBfpllA

Teacher script:

- *Look at your group's tooth. Look closely at the size, shape and texture. Using the 3 point measurements that your teacher showed you, sketch a picture of your tooth in the space provided on the first worksheet.*
- *What details do you notice about your tooth? Write down your observations.*
- *How long do you predict that your Megalodon was? Write down your prediction.*
- *Using the technique that I showed you, measure the crown height of your group's tooth in millimeters. Record your measurement. Be sure to work together so that everyone agrees on the measurement.*

Day 2 (Explore):

- *Now for the fun part! Today you will be using the same mathematical formula that scientists use to figure out the length of megalodon sharks. Using your megalodon tooth, you will figure out the length of the shark it belonged to.*



- *Step 1: Circle the tooth that your group is using: a1 a2 a3*

- *Step 2: Record the crown height of your tooth in millimeters.*

- *Step 3: Choose the correct formula for your tooth. Be sure to circle the formula you will be using.*

a1 TL= -8.216 + (14.895 X)

a2 TL= -7.643 + (13.597 X)

a3 TL= -10.765 + (17.616 X)

- *Step 4: Record the correct formula you will be using on the line provided. Check with your elbow partner to make sure they have written down the correct formula.*

- *Step 5: Multiply the crown height by the other number in parentheses. (Teachers, you may want students to use a calculator if they have difficulty with the math formula.)*

- *Step 6: Watch me as I add the negative integer to the total. (Students have probably not worked much with negative numbers, so I recommend demonstrating how to do this with a calculator. Show students what they would use for each tooth. Check for understanding before they work independently on the formula.)*

- *Ok. Add the negative integer to your total.*

- *Step 7: Now, you are going to move the decimal point 2 places to the left to convert from millimeters to meters. (Teacher should model this for the class before they work on their own.)*

- *Step 8: Now, round your new number to the hundredths place. (Teacher should walk around and check for understanding and accuracy.)*

- *Step 9:Using the calculator, multiply your new number by 3.28. This will convert your answer to feet. Can anyone tell me what unit our previous number was in? (Meters)*

- *How long was YOUR megalodon?? Wow! Were you surprised by your findings? Why or why not? Please take some time to record your thoughts on the lines provided on your worksheet. If anyone was not able to find the length of their shark, I will be walking around to help your group. (Teacher can then help some groups while others are recording their thoughts.)*

Day 3

- *Today we are going to actually measure out and look at the length of our megalodons. Using string and a measuring tape, measure the length of your Megalodon. Tape the string to the ground so that it doesn't move.*
- *Now, choose a member of your team to lay next to the string. Figure out how many of him/her it would take to reach the length of your shark. How many students did it take to reach the length of your shark? Be sure to record your findings.*

Explain:

- *Given the large size of the Megalodon and its enormous teeth, why do you think this species went extinct? Talk with your group. Record your thoughts on your worksheets.*

Day 4 (Elaborate):

- *Today we are going to read the article, Megalodon Mystery: What Killed Earth's Largest Shark? Please turn to this article in your packet. Before reading the article, we are going to hunt for unfamiliar words. In your groups, work together to can the article and underline any words that are new to you. Then discuss what you think the words mean in your group. (Give students time to do this activity while moving about the classroom checking on progress.)*
- *Were there any words that were new to your group? (Discuss as whole class. Provide definitions for unfamiliar vocabulary.)*
- *(Teacher can decide if this article should be read as a whole class, individually, or with a partner.)*
- *What points does the article make regarding possible reasons for the extinction of the megalodon? Think about the amount of energy that would have been necessary for this shark to survive. (Have student groups discuss. Pass out chart paper and have groups record their responses on the paper.)*
- *(When students have completed their posters, do a gallery walk and let students look at the ideas of their classmates.)*

Day 5 (Evaluate):

- *Yesterday you read about possible reasons for the extinction of the megalodon. Today we are going to watch a video about shark conservation. As you watch the video, I want you to think about how it relates to the megalodon. (Teacher should now play the following link.)* *https://www.flmnh.ufl.edu/rentmegalodon/videos/*

- *Why do you think learning about the Megalodon is important? Is it relevant today? Using information gathered from your observations, reading, group posters, and discussions, you are going to write 1-2 paragraphs on the importance of the megalodon. Be sure to explain your thinking and to give examples to support your ideas. (Teachers, you may want to scaffold the writing depending on the levels of your students. Helping students with the first topic sentence may be helpful.)*

The final writing activity is a summative assessment of students' understanding. Students should provide a reason for why they think learning about the megalodon is important AND provide examples and reasons for their thinking.

Optional Extra Activity

There is a fascinating video about megalodon nurseries. There is also an article that the teacher can use for background information. We tend to view these massive sharks as violent- but learning about how they cared for their young and had nurseries to protect them, is a great lesson in species survival. Great Whites have shark nurseries for their young. The commonalities between the two sharks is an interesting conversation.

Videos on Megalodon nurseries and shark conservation from the Florida Museum of Natural History
https://www.floridamuseum.ufl.edu/rentmegalodon/videos/

Ancient Nursery Area for the Extinct Giant Shark Megalodon from the Miocene of Panama
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0010552

STANDARDS (NGSS)

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproductions.

Performance Expectation	Connection to Lesson
4-LS1-1 Molecules to Organisms: Structures and Processes Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.	Students will learn about features of the megalodon that helped it survive (ex: teeth and body size). Students will also learn and discuss different theories regarding its extinction and how that may have related to the megalodon's structures.
Science & Engineering Practices	**Connection to Lesson**
4-LS1-1 Engaging in Argument from Evidence: Construct an argument with evidence, data, and/or a model.	Using data from 3D models as well as articles, students will make a hypothesis regarding the reason for the extinction of the megalodon.
Disciplinary Core Ideas	**Connection to Lesson**
4-LS1-1 Structure and Function: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	Students will use a mathematical formula to figure out the length of a megalodon by using one of its teeth. Students will also investigate the properties of the teeth that would have been a valuable adaptation.
Crosscutting Concepts	**Connection to Lesson**
4-LS1-1 Systems and System Models: A system can be described in terms of its components and their interactions.	The megalodon was an apex predator due to its size and teeth. The energy needed for this massive shark to survive will be investigated and discussed by students.

CCSS STANDARDS (http://www.corestandards.org/Math/)

Solve problems involving measurement and conversion of measurements.
CCSS.MATH.CONTENT.4.MD.A.1

Use place value understanding and properties of operations to perform multi-digit arithmetic.
CCSS.MATH.CONTENT.4.NBT.B.5

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.
http://www.corestandards.org/ELA-Literacy/

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.

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.

RESOURCES & MATERIALS

- Giant Megalodon Biggest Shark 2014 Prehistoric Predators Nature Wildlife Documentary
https://www.youtube.com/watch?v=tkHIGBfpllA
- Why Are Sharks so Awesome? Ted Ed Video
http://ed.ted.com/lessons/why-are-sharks-so-awesome-tierney-thys
- Megalodon Educator's Guide from the Florida Museum of Natural History
https://www.floridamuseum.ufl.edu/wp-content/uploads/sites/16/2017/03/Megalodon-Educators-Guide.pdf
- Videos on Megalodon nurseries and shark conservation from the Florida Museum of Natural History
https://www.floridamuseum.ufl.edu/rentmegalodon/videos/
- *Ancient Nursery Area for the Extinct Giant Shark Megalodon from the Miocene of Panama*
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0010552

KEY ACADEMIC AND/OR SCIENTIFIC LANGUAGE

List the terms used in the lesson and definitions (e.g., deep time, brachiopod etc.).
Some of the many paleontology glossaries:

Adaptation: Any heritable characteristic of an organism that improves its ability to survive and reproduce in its environment. Also used to describe the process of genetic change within a population, as influenced by natural selection. Alternatively, some heritable feature of an individual's phenotype that improves its chances of survival and reproduction in the existing environment.

Cartilaginous fishes: Class Chondrichthyes; fish having a skeleton composed mostly of cartilage, as sharks and rays. Cartilage is gristle or a firm, elastic, flexible type of connective tissue. (USGS Paleontology glossary)

Fossil: mineralized or otherwise preserved remains or traces (such as footprints) or impressions of animals, plants, and other organisms. (from Wikipedia glossary); Evidence of past life on earth. Can include the preserved hard and soft parts of plants and animals, tracks and burrows, whole organisms preserved intact in amber or tar, and fossilized dung. Any evidence of life constitutes a fossil. (GeoMan)

Fossil record: the history of life on Earth through geological time, as preserved through fossil remains in sedimentary rock (sometimes referred to poetically in older books as the record of the rocks). Also, the fossil history of any particular group.

Fossilization: All the processes that involve the burial of a plant or animal in sediment and the eventual preservation of all, part, or a trace of it. (USGS Paleontology glossary)

Metabolism: the uptake and digestion of food, and the disposal of waste products in a living organism, including synthesis of organic molecules (anabolism) and their breakdown (catabolism). This is to be distinguished from cell metabolism which is the process of metabolism occuring within a single cell. Cell metabolism is the process by which individual cells process nutrient molecules.

Natural selection: The differential survival and reproduction of classes of organisms that differ from one another in on or more usually heritable characteristics. Through this process, the forms of organisms in a population that are best adapted to their local environment increase in frequency relative to less well-adapted forms over a number of generations. This difference in survival and reproduction is not due to chance.

Organism: individual member of a species, that is, a single biological entity.

Paleontology: The scientific study of ancient life (palaeos = ancient, ontos = being, logos = speech, reason, hence study of), through examination of fossil remains and the fossil record. Includes subdivisions such as Vertebrate, Invertebrate, and Micro- paleontology. Paleontologists have access to many extinct forms of life, including many transitional and ancestral forms, and information regarding their stratigraphic or temporal position in the geological timescale, paleobiology, paleoecology, paleoclimatology, etc extend this to environmental, geographic, and other areas to provide a comprehensive history of the Earth. Because of the fragmentary or partial nature of many fossils, reconstructing extinct life and extinct environments is often more like forensic science than biology or ecology. (MAK)

Species: An important classificatory category, which can be variously defined by the biological species concept, cladistic species concept, ecological species concept, phenetic species concept, and recognition species concept. The biological species concept, according to which a species is a set of interbreeding organisms, is the most widely used definition, at least by biologists who study vertebrates. A particular species is referred to by a Linnaean binomial, such as Homo sapiens for human beings. Also see tree of life section.

http://palaeos.com/paleontology/glossary.html
http://www.fossilmall.com/Science/Glossary.htm

PRIOR KNOWLEDGE

Students do not need to have any background knowledge before this lesson. In third grade students studied animal adaptations so a brief review of this may be helpful. These lessons are a great introduction to studying sharks. Students learning about how one of the biggest sharks went extinct, sparks curiosity into the sharks that are alive today.