Implementing a constructivist teaching model for conceptualizing geologic time

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Constructivist Teaching Model

Following a four-phase constructivist-learning model (Yager 1991) shown in Fig. 1, middle school students are guided through sequencing the major events of Earth's history and constructing meaning from the geologic time scale.

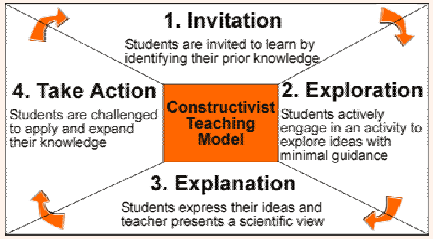

Fig. 1. Diagram of the four-phase constructivist teaching model

1. Invitation

- Purpose - Spark student interest, assess student prior knowledge, and expose students ideas about a topic.
- Teacher's role - Provide provocative questions, perform a demonstration for students to ponder, or ask students what they have heard on the topic.
- Students' role - Share their knowledge or information about the topic.
- Goals – Teachers identify preconceptions that need to be altered later in the lesson and students identify ideas that can be linked to the new concept.

To begin the geologic time lesson, invite students to learn how Earth's past is measured and recorded by giving each student a card with a role and a task. To differentiate instruction, teachers can work individually with each small group.

Facilitator (keeps track of time) List some big events that you have heard occurred last year.	Recorder (writes group answers) List some big events that you have heard occurred in the US since 1776.
Communicator (speaks for the group) List some big events that you have heard occurred more than one million years ago.	Materials Manager (manages supplies) How is a "big event" in geologic time different than a big event in calendar or historical time?

Fig. 2. Note cards for organizing roles and tasks

Identifying Prior Knowledge about Geologic Time

Teachers can facilitate a short whole-class discussion about geologic time by recording the big events listed, discussing how geologists define geologic time, and then editing the big events list.

Draw a rectangular box on the board divided into 10 equal rows. Label each line starting at the top with today, 100 MYA, 600 MYA and continue until 4,600 MYA. Ask students where the big events might fit into this table. Shade in the bottom 9 rows and explain that this represents the Precambrian Era. Most of the events on the "big events" list occurred after the Precambrian Era (in the top row.)

2. Exploration

- Purpose - Provide a focused activity that allows students to develop an understanding of the concepts.
- Teacher's role - Provide an experience for students to further develop their ideas.
- Students' role - Discuss and work collaboratively in groups to refine their knowledge.
- Goals – Students become actively engaged in interacting with ideas as teacher facilitates learning with minimal guidance.

During the second phase of the geologic time lesson (Fig. 3), students are given a set of informational clues (Fig. 4) and a blank geologic time scale chart (Fig. 5). Students work in cooperative groups to investigate what geologists consider to be "big events" and fit them into a geological timeline.

Fig. 3. Geologic time lesson

Materials (per group of 4)
- 1 set of Clue Cards (Figure 4)
- Pencil
- 4 Incomplete Geologic Time Scales

Setup
1. Photocopy clue cards on different colored paper and then cut along the lines of the cards.
2. Shuffle all the cards thoroughly.
3. Photocopy incomplete geologic time scales. One per student.

Procedure
1. Look over every note card.
2. Group all of the note cards based on geologic period or time. There should be at least one note card for each geologic time period.
3. Write down each clue on the note card in its correct geologic time period.
4. There are enough bullets in each geologic time period to match the events.

Fig. 4. Informational clues are cut into cards and given to students to sort

During the Quaternary period, present day *homo sapiens* (humans) began to inhabit the Earth.	208 million years ago, largest dinosaurs appeared, such as Stegosaurus, Diplodocus, and Apatosaurus	During the Tertiary period, 1.6 million years ago, a continental glacier formed over Antarctica. It is still there today.	During the Tertiary period, the first sea mammals, such as the whale and the dolphin, began to develop.
Tyrannosaurus Rex began to appear during the Cretaceous period, which ended around 66.4 million years ago.	During the Jurassic period, the first flying animals, such as the birds and flying reptiles, began to appear.	At the end of the Triassic period, Pangaea began splitting apart.	The Triassic period was known as the "Age of Reptiles" because reptiles such as turtles, crocodiles, and dinosaurs became abundant.
The first mammals, which evolved from the warm-blooded reptiles, began to develop in the Triassic period.	The super continent Pangaea formed during the Permian period, which was 245 million years ago.	There were very few fossils of many land and sea animals, and no fossils of dinosaurs, found after the Cretaceous period.	During the Permian period, the southern region of Pangaea was in an ice age.
The first warm-blooded reptiles began to develop around 245 million years ago.	During the Carboniferous Pennsylvanian period, the first reptiles developed. Also, large swamp forests made of huge trees were abundant.	Sharks, fish, and amphibians were common during the Carboniferous Mississippian period, which was 320 million years ago.	We were unable to locate any fossils from many species of invertebrates after the Permian period.
During the Devonian period, the lungfish developed.	The Devonian period, ending about 360 million years ago, was known as the age of fishes. Fish with scales and bony skeletons developed during this time period.	There were many plants during the Cretaceous period.	During the Silurian period, the first fish with jaws began to develop.
Around 438 million years ago, the first fish began developing in the sea. These fish were jawless.	During the Ordovician period, the first fish, which were jawless, began to develop.	During the Cambrian period, there were large amounts of trilobites, brachiopods, sponges, and other sea invertebrates.	During the Precambrian period, oxygen began building up in the atmosphere.

Geologic Time Scale

Era	Period	Millions of years ago	Notes
Cenozoic	Quaternary	-	-
	Tertiary	-	-
Mesozoic	Cretaceous	-	-
	Jurassic	144	-
	Triassic	206	-
Paleozoic	Permian	-	-
	Carboniferous Pennsylvanian	292	-
	Carboniferous Mississippian	-	-
	Devonian	-	-
	Silurian	408	-
	Ordovician	-	-
	Cambrian	505	-
Precambrian		- Early life forms on the Earth (bacteria, algae, jellyfish, corals, and clams). This era accounts for close to 88% of Earth's history	

Fig. 5. Blank Geologic time scale given to each student to complete with data from the informational clue cards

3. Explanation

- Purpose - Enable students to construct new views of the concepts based on their experience with the activity.
- Teacher's role - Allow students to communicate their new understanding of the topic.
- Students' role - Share ideas with the class.
- Goals – Students present their ideas and teacher introduces the scientific view of the concept.

The third phase of the geologic time lesson, explanation, asks students to share and discuss their findings and modify their geologic time scales (Fig. 6). Through a series of questions, students are then asked to utilize the geologic time scale as a reference.

Geologic Time Scale

Fig. 6. Completed geologic time scale

Era	Period	MYA	Notes
Cenozoic	Quaternary	• *Present*	• *Present day humans begin to inhabit Earth.*
	Tertiary	• *1.6*	• *First sea mammals, such as dolphins and whales, appear.* • *Continental glaciers formed over Antarctica.*
Mesozoic	Cretaceous	• *66.4*	• *There were many plants in the Cretaceous period.* • *Mass extinction at the end caused extinction of a large amount of land and sea life, including the dinosaurs.* • *Tyrannosaurus rex begins to appear.*
	Jurassic	144	• *First birds and flying reptiles begin to appear.* • *Largest dinosaurs appeared such as Stegosaurus, Diplodocus, and the Apatosaurus.*
	Triassic	208	• *First mammals, which evolved from warm-blooded reptiles, appeared.* • *First dinosaurs, turtles, and crocodiles.* • *"Age of Reptiles"* • *Pangaea begins splitting apart at the end of this period.*
Paleozoic	Permian	245	• *A mass extinction at the end wiped out many invertebrates.* • *First warm-blooded reptiles began to appear.* • *Most of the south was in an ice age.* • *Super continent Pangaea formed.*
	Carboniferous Pennsylvanian	292	• *First reptiles began to appear.* • *Large swamp forests made of huge trees covered North America and parts of Europe.*
	Carboniferous Mississippian	• *320*	• *Fish, sharks, and amphibians common.*
	Devonian	• *360*	• *Lungfish develops.* • *"Age of Fishes"* • *Fish with scales and bony skeletons common along with sharks.*
	Silurian	408	• *Fish with jaws begin to develop.*
	Ordovician	• *438*	• *First fish, which were jawless, begin appearing in the sea.*
	Cambrian	505	• *Large amounts of trilobites, brachiopods, sponges, and some other sea invertebrates.*
Precambrian			• *Oxygen begins building up in the atmosphere.* Early life forms on the Earth (bacteria, algae, jellyfish, corals, and clams). This era accounts for close to 88% of Earth's history

Discussing The Geologic Time Scale

Questions for whole class discussion may include the following:

- Why are there only three eras in the geologic time scale?
- Why is "Age of Reptiles" a big event in the Triassic period?
- How do scientists know that the Devonian period was the "Age of Fishes?"
- How long does a geologic time period last?
- Why is the beginning of the Paleozoic era known as the "Cambrian explosion?"
- How is the "Cambrian explosion" a big event in Earth's history?
- What patterns of evolution are revealed in the time scale?
- Why would Earth's atmosphere contain 50% more oxygen during the Cretaceous period than it does today?

4. Take Action

- Purpose - Engage students in applying and extending their knowledge on the science concepts.
- Teacher's role - Help students take a position about an idea related to the concept.
- Students' role - Apply knowledge and skills, ask new questions, or make decisions.
- Goals – Teacher presents a challenge or issue for students to apply or extend their understanding of the topic.

"Take action" is the final phase of the geologic time lesson and can be completed either in class or at home. Students can be given a picture or story (Fig. 7) to demonstrate the geologic knowledge they have constructed. Student assessment is based on using and thinking about the geologic time scale.

Fig. 7. Assessment activity and rubric

Life Reaches Land Millions of Years Ago

The image is an artist's rendition of a prehistoric time period. Using your geologic time scale, determine the Era and Period of the scene. Write a paragraph explaining your answer. Consider the following questions for supporting your response:

IMAGE CREDIT: John Sibbick

1. How does the plant life belong to the geologic time chosen?
2. What type of animals existed during this time?
3. How does the evolutionary sequence show that the animals belong during the geologic time?

Uses correct grammar, punctuation, and spelling.	1
Correctly chooses a time period depicted in the image.	1
Provides accurate information about the plant life of the time period.	2
Correctly identifies where the animals belong in an evolutionary pattern.	2
Includes facts from the geologic time scale for support.	2
Total possible points	8

Essential Follow-up Questions

This lesson fosters the development of the following essential questions:

- How do scientists determine the dates for geologic time?
- How are the geologic periods named?
- What evidence supports the information included in the clues?

These questions can guide student learning throughout a geological unit of instruction.

Literature cited

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For further information

Please contact *jpscience@bellsouth.net*. A more detailed lesson can be found in the article ***Where in Time?*** in the October 2005 issue of Science Scope. This poster is available in PDF-format on-line at *www.engagedtolearn.com*.

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