Developing and Using Science and Engineering Practices (by Lesson)

Lesson	Elements of Science and Engineering Practice(s)	Rationale
1	Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	Students' questions for the Driving Question Board (DQB) emerge from their observations of video clips, from information in a reading passage, and through engagement with a computer interactive displaying a timeline of seismic (earthquake) events and their geographic distribution around the world. Students use their questions to develop models to explain the typical patterns of Mt. Everest's growth and movement, as well as the exceptional movement observed during one recent earthquake.
1	Develop and/or use a model to predict and/or describe phenomena.	Students develop an initial model to explain how Mt. Everest typically grows and moves gradually over time, while also accounting for the more atypical, sudden movement seen during a recent earthquake.
2	Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.	On day 2, students examine mapped data and topographical maps of specific locations to identify patterns in earthquake data in that location compared to other locations, and to identify relationships to topographical features in the area.
2	Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.	Students use the Seismic Explorer tool to display a large data set of earthquake activity. On day 1, they use this tool to identify patterns in earthquake activity in the Himalayas, worldwide, the U.S., and even near their hometown. Students zoom in and out of locations to change the spatial scale, and also adjust time frames to see how changing these scales allows different patterns to emerge.
3	Analyze and interpret data to provide evidence for phenomena.	Students will collect data from text about how earthquakes are measured and how this links to the patterns students observed in lesson 2. On day 2, students will read about how GPS data is collected. Then they will analyze some data about how fast different plates are moving and the direction in which plates are moving. Using this data, the class will reconvene around the DQB and compare this data to the predictions made about where the 9 major plates could be located.
3	Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	Students will engage with scientific text twice during this lesson. The first article will include information about how earthquake data has been collected in the past through today, and how this data is used to record patterns and make predictions about when and where earthquakes will happen in the future. Students will use what they figure out from the reading to construct an argument about where different plates are located on Earth.
4	Develop and/or use a model to predict and/or describe phenomena.	Students develop a model to represent Earth's surface consisting of plates that are made of different materials and increased temperatures at greater depths.
5	Develop and/or use a model to predict and/or describe phenomena.	Students will revise their Earth models from Lesson 4 to include the makeup of the plates and what is below the plates. In this lesson, students figure out that the plates are part of the Earth's crust and below this layer is the mantle, a very hot rock of an asphalt consistency. Once students have revised their models, they will determine what else should be included in their models.

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5	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students read an article about the different layers of the Earth. Up to this point, students know there are plates on Earth, but we do not know what is below the plates. After reading the article, students learn that there are different layers: the crust, the mantle, and the core. Using what they read, students revise their Earth model from Lesson 4 to include information from the reading about what is under the plates.
6	Develop a model to describe unobservable mechanisms.	Students develop a model to represent ideas for how energy flows and matter cycles in the mantle, and how this causes different movement of the plates at the surface of Earth.
6	Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	Students apply mathematical concepts and processes to make connections between the direction of energy flow and matter cycling in the mantle to the directional movement of plates at the surface. Additionally, they consider that if the source of energy was stronger and/or the rate of energy transfer were faster, how it would impact the speed of movement at the surface.
7	Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	Students use evidence from previous lessons to figure out how far the Indian and Eurasian plates have moved over time. To collect data about how the plates have moved, students use a point on the boundary between the two plates. This collected data will show how much these two points have moved over time and will also predict how they will move in the future.
8	Develop and/or use a model to predict and/or describe phenomena.	On day 1, students revise their initial model from Lesson 1 to explain the different kinds of movement at Mt. Everest. On day 2, they develop a new model for explaining the phenomena observed at locations where plates diverge.
8	Construct an explanation using models or representations.	On day 2, students construct an explanation to explain gradual and sudden changes to Earth's surface based on the motion of plates and convection in the mantle. They do this in the context of Mt. Everest as an example location where these gradual and sudden changes occur.
9	Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.	Students analyze cross-sections of large-data sets to identify patterns and provide evidence to support scientific theories that plate sinking back into the mantle is the cause of volcanoes to form in some places.
9	Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	Students integrate information and data from four sources in this lesson (a video, an animation, a reading, and a graphical display of data in a visualization tool) to build ideas for how volcanoes form in some places. Earthquake data is used to support claims made in previous readings and media.
10	Develop a model to describe unobservable mechanisms.	Students are developing and revising models on Day 1 of this lesson. First, they review the consensus models representing a cross-section of three types of plate movement. Then they develop a new synthesized representation of these ideas to look for similarities and differences across the different types of plate movement.

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10	Construct an explanation using models or representations.	In the mid-point assessment, students construct explanations using models to predict and explain the location of mountains and earthquakes. They draw cross-section models of these processes to explain both mountain-building and volcanic formation.
10	Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Students apply scientific ideas and evidence to construct an explanation for how the mantle interacts with the plates to cause different kinds of movement. The movement at the plate boundaries can be used to explain the earthquake patterns and landforms associated at that boundary.
11	Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.	Students read an article from an interview with a geologist about how fossils have been found at the top of Everest. As they read, they formulate new questions about Mt. Everest and how it has changed over time.
12	Analyze and interpret data to provide evidence for phenomena.	At the end of day 2, or beginning of day 3, after examining the rock layers of Mt. Everest and the time series map data, students individually use evidence to explain what the location of Mt. Everest may have looked like in the past, and how an ancient sea fossil could be found on Mt. Everest.
12	Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Near the end of the lesson on day 3, students will update their Progress Trackers in their notebooks by constructing an explanation that answers the question, "Why do we see the fossil of an ancient sea creature near the top of Mt. Everest?"
13	Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	Students visit stations and share information with one another about what they have observed. Using information from the stations, students justify which data source best explains the pictured changes.
13	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students read about different conditions in which weathering and erosion occur in the natural world. Each reading at each station provides information to better understand how weathering and erosion occurs within the natural and designed world, and the information will be used to justify and explain what has occurred in the presented images.
14	Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	Students develop a time-series model to show the relationship between uplift and erosion that can account for how a fossil could get to the top of Mt. Everest and become exposed for climbers to see.
14	Use mathematical representations to describe and/or support scientific conclusions and design solutions.	Students reason about the relationship between uplift and erosion rates to determine whether a mountain is growing taller or shrinking in elevation.
14	Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Students apply scientific ideas and evidence to construct explanations to explain different phenomena in the world: a "wall of bones," two mountains ranges in the US, and a recent crack in eastern Africa.

Developing and Using Crosscutting Concepts (by Lesson)

Lesson	Elements of Crosscutting Concept(s)	Rationale

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1	Graphs, charts, and images can be used to identify patterns in data.	Students make observations about patterns that emerge across time and spatial scale when examining earthquake data in a region over a short period of time as compared to the world over the same time and longer periods of time. They compare evidence (video, reading, earthquake data) indicating that earthquakes create sudden changes during a single event, but over time appear to occur in patterns in certain locations around the world.
1	Phenomena that can be observed at one scale may not be observable at another scale.	Students make observations about patterns that emerge across time and spatial scale when examining earthquake data in a region over a short period of time as compared to the world over the same time and longer periods of time. They compare evidence (video, reading, earthquake data) indicating that earthquakes create sudden changes during a single event, but over time appear to occur in patterns in certain locations around the world.
1	Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	Students use a model to describe how Mt. Everest exhibits a regular pattern of gradual movement and growth each year, but shifted suddenly during a single geologic earthquake event. Students use this idea of gradual and sudden movement as they start to explain what could be happening with Mt. Everest and ask questions about what is causing both kinds of movement.
2	Graphs, charts, and images can be used to identify patterns in data.	On day 2, students are assigned a location known for earthquake activity for closer analysis. They use satellite imagery maps, relief maps, street maps, and earthquake data to identify the local pattern in earthquake activity compared to patterns worldwide. They also compare this earthquake pattern to satellite imagery and relief maps to identify potential patterns in earthquake locations and the presence of local landforms.
2	Phenomena that can be observed at one scale may not be observable at another scale.	On day 1, students explore patterns in earth activity at different spatial and temporal scales. Students begin their investigation by characterizing the patterns in earthquake activity in the Himalayas. Students then zoom out to compare the Himalaya pattern to patterns worldwide, followed by looking for patterns in earthquake activity in the United States, students' home state, and town. Students will also compare patterns that emerge in shorter and longer time scales. This process of zooming in and out at different spatial scales, and shortening or lengthening the time scale, will help students identify patterns in earthquake activity when looking at different spatial and temporal scales.
3	Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.	Students will use the crosscutting concept of patterns multiple times during this lesson. From the previous lesson, students will have seen that there are patterns around the globe to where earthquakes occur. Using information from two articles, students will learn that the surface of the Earth is not one continuous piece of land, but many pieces or plates, that are moving in different directions. They will notice that earthquakes tend to occur where plates interact.
3	Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.	Students consider to directions and speeds of plates as the are moving in relationship to one another. They find eight locations on Earth's surface and use that information to map the direction and speeds on the class map and consider the relative motion across the plates, indicating that they are separate pieces of crust moving at different rates of speed and in different directions.

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4	Graphs, charts, and images can be used to identify patterns in data.	Students use cross-section data to study bird's-eye and side view angles of earthquake activity to identify patterns of where earthquakes occur and how deep they occur at different plate boundaries.
4	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.	Students develop and use a model to represent how the structure and composition of the different plates on Earth will contribute towards their function (in Lessons 8-10).
5	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	Students further revise their Earth model to include other parts of the Earth system: the layers of the Earth.
5	Models can be used to represent systems and their interactions—such as inputs, processes andoutputs—and energy, matter, and information flows within systems.	Towards the end of the lesson, students begin to construct an understanding of the cycling of thermal energy within Earth's interior by revising their Earth models to include how energy transfers from the core through the layers of the Earth.
6	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	When students revise the Earth Model to account for ideas about energy flow and matter cycling, they are working across subsystems of Earth: the core (heat source), the mantle (medium in which energy is transferred to the surface), and the crust (the surface expression of that movement in the mantle). Students will draw each part of the system and account for how one part interacts with another part of the system.
6	Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.	Students focus on how the energy transfer from the mantle to the plates is driving the motion of the plates and also on the cycling of matter between the mantle and the crust.
7	Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.	Using the current motion of the plates (rate in cm/year and direction), students determine that two points on the edge of the Indian and Eurasian plates were 7.5 cm apart one year ago. They measured how far apart the two points would have been 10 years ago and figure out that the points were 75 cm apart on the scale of our map. Using the discovery that there is a proportional mathematical relationship for how this distance increases over time, students work with a partner to determine how far apart these two points would have been 100 years ago, 1,000 years ago, and 100,000 years ago.
7	Phenomena that can be observed at one scale may not be observable at another scale.	Students are able to see an aspect of the phenomena that can be observed at one scale that was not observable at another scale in this lesson. The observable aspect of the phenomenon was a very small amount (cm) of movement in a plate in a particular direction over a year. This is in line with what might be expected from a phenomenon like an earthquake. By scaling this rate of motion over geological time frames, they are able to see a very different aspect of the phenomena - that plates move vast distances (kilometers) over millions of years and therefore, the location of the continents in the distant past could have been in very different locations.

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8	Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	Students figure out that Mt. Everest has predictable and gradual movement in one direction (northeast). Earthquake events disrupt or disturbed this gradual change, sometimes in very significant ways. Students should use the lens of Stability and Change to develop their model explaining movement at Mt. Everest and construct an explanation for the quick and slow changes on the surface of Earth.
9	Graphs, charts, and images can be used to identify patterns in data.	Students use the cross-section pattern in earthquake data and various depths to support whether or not a plate is sinking below another plate.
9	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	Students consider how the mantle (and movement in the mantle) causes plates to move in different directions at the surface. One movement in particular, a heavy plate colliding with a lighter plate, causes the heavier plate to sink back into the mantle under the lighter plate. When this plate interacts with the other plate, it causes earthquakes to occur at greater depths as it sinks. When it interacts with the mantle, it begins to become very, very hot and melt, putting pressure on the crust above and pushing magma to the surface causing volcanoes to form. Students focus on the different parts of the system (two plates and the mantle) to understand volcano formation.
10	Patterns can be used to identify cause and effect relationships.	In the mid-point assessment, students predict the pattern of mountain building and earthquake activity based on the provided plate movement. They construct cross-sections of the plate movement to support the pattern they identify.
10	Grades 3-5: A system can be described in terms of its components and their interactions.	The time and spatial scales at which the plate boundaries interact are too long and too large to be studied without the use of models. Students use top-down and cross-section models throughout the unit to explain patterns in earthquake activity, landforms, and other features at different boundary types. Using models like these is one of the primary ways to study systems at such large spatial scales that operate over time scales of millions of years.
10	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	The sub-systems of Earth (the core, the mantle, the broken crust) interact in ways that shape the Earth from below. Students explain the interaction between the processes in the mantle and how they cause the plates to move in different ways at the surface. It is this movement at the surface that causes plates to collide or spread apart, causing different patterns of earthquakes and landform creation.
11	Grades 3-5: A system can be described in terms of its components and their interactions.	Students use our model of how the Earth has been changing at Mt. Everest to explain how it has moved over the last 50 million years. After reading the interview about fossils of sea creatures from 400 million years ago being found on Mt. Everest, students realize our model can't explain back this far in time.
12	Phenomena that can be observed at one scale may not be observable at another scale.	At the end of day 2 and day 3, students have opportunities to analyze and interpret data in order to understand how past plate motion on Earth's surface helps to explain the locations of both sea- and land-creature fossils around the world, as well as at higher elevations. Students' explanations regarding the relative positions of Earth's surface features (i.e. continents and oceans) indicate their sense of geologic scale.

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13	Cause and effect relationships may be used to predict phenomena in natural or designed systems.	Cause and effect is utilized to determine the weathering and erosion process. By looking at the effects and learning the varying processes through which the environment changes, students are able to determine the reasons behind the changes that have occurred in the landscape images and on Mt. Everest.
13	Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.	Weathering and erosion are both processes that can occur at different time scales. Students engage in the crosscutting concept of change over time by learning about the processes in stations, identifying acting forces with the class, then using time-lapse videos to determine if the forces occur at a slower or a faster pace. Students identify that most weathering and erosion happens over a longer period of time which is hard to observe, but sometimes can happen very rapidly.
14	Grades 3-5: A system can be described in terms of its components and their interactions.	Students use a time-series model to account for the major timepoints between the fossilization of a marine fossil (hundreds of millions of years ago in an ancient seabed) to its place on top of Mt. Everest today.
14	Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.	Students reason about the relationship between uplift rates (mm/yr) and erosion rates (mm/year) to consider how much a mountain is either growing taller or shrinking in elevation.
14	Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.	Students construct explanations about the stable processes of growth and decline in mountains ranges over millions of years, considering how mountains change over time. These explanations also include how the fossil record can account for what places were like long ago and how they changed over time to what they are today.