Dynamic Earth: How is this place on Earth going to change over 10, 100, 1 000, 10 000, and 1 000 000 years?

Primary: (ages 7-11)	Earth Science

In this unit, students consider a number of open questions about how landforms and Earth surfaces are constantly changing due to a variety of factors that can be observed and investigated. They observe and compare the features of landforms to identify patterns of rapid and slow changes to Earth features. They consider how such observations help scientists develop accurate predictions for changes to unfamiliar places. Students apply these ideas to explain phenomena and design solutions to problems they experience in their environment

Time allocation	About 10 lesson periods
Subject content	Carry out observations and investigations and develop models to predict change to landforms and Earth surfaces . Develop and revise a model with evidence to show how various variables are changing land features.
Creativity and critical thinking	This unit has a **creativity** and **critical thinking** focus: • Generate and play with a variety of ideas and propose, produce, and revise a personally novel model of how land is changing. • Reflect on models according to evidence collected across the unit and consider different perspectives for what is causing change in different places.
Other skills	Collaboration, Communication,
Key words	Landforms;, rapid and slow changes; energy; observation; prediction

Products and processes to assess

Students develop their collaborative, creative, modelling skills by sharing ideas, carrying out investigations, making observations, constructing and revising models, and using models and ideas to explain phenomena.

Authors: Miller, E., Peek-Brown, D., Codere, S., Severance, S., Sturk, J., DellaVecchia, G., Severson, A., Palincsar, A., Krajcik, J. (2020) for the OECD for the CERI project *Fostering and assessing creativity and critical thinking skills*.

Teaching and Learning plan

This plan suggests potential steps for implementing the activity. Teachers can introduce as many modifications as they see fit to adapt the activity to their teaching context.

Step	Duration	Teacher and student roles	Subject content	Creativity	Critical thinking
	(Preparatory phase)	Prepare several different locations with various landforms or bring students to a nearby park or other location for them to make observations throughout the unit.			
1	Lesson periods 1 and 2	**In what ways is our place on Earth changing right now?** The teacher displays various photographs of different locations or brings students to a nearby location with interesting landforms. Students are introduced to the unit driving question, make observations, and think about what could be changing right where they are standing or in the photographs. Students look for changes taking place. They add these changes to a white board in two columns: fast changes or slow changes. Students make claims that some changes happen quickly and others slowly. They consider what evidence supports their claims. They think about change as energy in a system.	Making observations about local places changing and making claims about fast and slow changes from an energy perspective.	Imagining: Explore, seek and generate new ideas.	Inquiring: Understanding the context, frame and boundaries of the problem.
2	Lesson period 3 and 4	**How can we model fast and slow change in an Ecosystem?** Examine a photograph of a local place. The teacher uses the photograph to make a model of the place. She works with the students to figure out a symbol for slow change and one for fast change. The students collaboratively make models of the local place using both symbols to show one slow and one fast change. The model can be a drawing or a physical model with sand or clay or another material. Students present their models using a Museum walk. Each student writes at least one comment and a question. Students work in their groups to respond to the questions and comments, then look for some patterns across the models. They ask and post questions about change and energy on the Driving Question Board.	Developing models to compare fast and slow changes and using symbols identified through class consensus.	Reflecting: Assess the model and how it can more effectively show change to the land.	Imagining: Identify strengths and limitations of evidence in a model. Doing: Justify reasoning for model components.
3	Lesson period 5	**What do our families know about how places change?** Students bring interviews and photographs or drawings of a place that is changing that a family member shared with them. One by one, they present and record the information as evidence. Students compare the fast and slow changes across the places shared, and the causes and effects of those changes in a chart. They argue that places are similar or different with	Presenting and comparing information about places that families are familiar with and how they change.	Inquiring: Make connections to other concepts or ideas,	Imagining: Identify and review alternative theories and opinions and compare or imagine different

		respect to the changes that have happened, and will continue to take place.		integrate other perspectives.	perspectives on a problem.
4	Lesson period 6	**Does water shape the land, or does land shape the water?** Students observe photographs or actual objects to consider analogies for how water interacts with the land (broom and trash; slide and person going down the slide; pool balls bouncing off one another, scouring brush and pan, and snow scraper and snow on a windshield). Students, in groups, are given three examples to work with and collaborate to fill in the sentence: "A ____ and a _____ are like how land and water interact because _____." Students may draw a picture to go along with their sentence. Groups present their thinking to the large group and debate one group's analogy. Ask new questions. (Note: all the analogies can work to describe the relationship between land and water.)	Developing models and analogies of the relationship between land and water using familiar materials. Justify the analogy and consider other analogies.	Imagining: Stretch and play with unusual, risky ideas.	Inquiring: identify and question assumptions, check accuracy of facts and interpretations, analyse gaps in knowledge.
5	Lesson periods 7, 8 and 9	**How can we use evidence to predict change to the land?** With the teacher's support, students work in groups to set up landscapes with the stream tables, adding two geological features (e.g., delta, canyon, cliff, gulley, meander, plain, etc.). Students work collaboratively to draw and write in their science notebooks a prediction of what they think will happen when they add water. Students add water to the stream table selecting fast and slow, and/or large amounts with small amounts of water. They compare the results of the investigation with their predictions. Students spotlight discussing what variables they didn't consider when making their prediction. Students work together to describe erosion and deposition and ask, "do they always happen together?" They argue for their position on the question, and rely on the water table for evidence to support the claims. Students create a new landscape, with different land features, and use the ideas they developed in lesson 8 to develop a collaborative model to predict the way the water will change the land. They can decide if the water amount will be slow / fast or large or small. Students revise the model and draw arrows to show where energy was transferred.	Planning and conducting an investigation to check predictions for how water and land interact.	Doing: Produce, share and revise a product, the investigation, in a novel way. Produce, share and revise a product, the model, in a novel way.	Doing: Planning, and developing, revising the investigation using new features. Developing and revising a model based on logical criteria.

6	Lesson period 10	Review the DQs and whether any have been answered and how, and review all the questions and ideas that have been added to the Driving Question Board (DQB). Students work with a partner to address the questions that have not yet been answered and to discuss what they have learned and in which areas they have developed new ideas about this subject.. Students consider one or more new photographs of interesting landscapes and make a claim with evidence that some changes to the land are slow and some are rapid, and that both slow and rapid changes involve the transfer of energy. Students make one another accountable to using evidence from the 10 lessons that will support claims.	Answering remaining questions. Using novel photographs to imagine new situations and use evidence from the ten lessons to support new claims.	Reflecting: Reflecting on and assessing the relevance of the variables affecting the land features.	Reflecting: Reflecting about what is causing land change in an unfamiliar location. Evaluating the knowledge developed.

Resources and examples for inspiration

Web and print

- Photographs of varied landforms
- Driving Question Board (DQB) to keep track of class and student questions
- Step 4 Analogy Slides
- Step 5 Land Features Slides

Other

- Household materials to build stream tables: containers, earth materials (sand and rocks)

Opportunities to adapt, extend, and enrich

- This mini-unit is based on portions of the first two learning sets in a sequence of five learning sets. Remaining learning sets have students examine how Earth events can cause layers in rocks, and how high energy events, such as earthquakes and flooding cause changes to the land. Students use patterns to understand data such as mountain ranges and shapes of rivers to predict future changes in landforms.
- Remaining learning sets, along with additional STEM project-learning units and related resources can be found at https://sprocket.lucasedresearch.org/course/science4/dynamic-earth and https://mlpbl.open3d.science/

ML-PBL Units were co-developed by the Multiple Literacies in Project-based Learning Project at Michigan State University and the University of Michigan 2018–2020.

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Creativity and critical thinking rubric for science

Mapping of the different steps of the lesson plan against the OECD rubric to identify the creative and/or critical thinking skills the different parts of the lesson aim to develop

	CREATIVITY Coming up with new ideas and solutions	Steps	CRITICAL THINKING Questioning and evaluating ideas and solutions	Steps
INQUIRING	Make connections to other scientific concepts or conceptual ideas in other disciplines	3	Identify and question assumptions and generally accepted ideas of a scientific explanation or approach to a problem	1, 4
IMAGINING	Generate and play with unusual and radical ideas when approaching or solving a scientific problem	1, 4	Consider several perspectives on a scientific problem	2, 3
DOING	Pose and propose how to solve a scientific problem in a personally novel way	5	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.)	2, 5
REFLECTING	Reflect on steps taken to pose and solve a scientific problem	2, 6	Reflect on the chosen scientific approach or solution relative to possible alternatives	6