When are rain events a problem for people, and what can we do about them?

Primary: (ages 7-11)	Science, Engineering

In this unit, students investigate weather and water events, and consider how they have changed in familiar areas. They interview relatives and gather information about people's personal experiences with weather. They investigate and model condensation and evaporation, considering how warmer temperatures would impact rain. Finally, students work in groups to design mitigation solutions for flooding caused by an extreme rain event.

Time allocation	About 12 lesson periods
Subject content	Weather vocabulary, weather systems, water cycle, water vapour, condensation, evaporation
Creativity and critical thinking	This unit has a **creativity** and **critical thinking** focus: • Design and conduct scientific investigations and evaluate their strengths and limitations. • Evaluate the impact that changing temperatures can have on the land and water flow in an area and consider remaining uncertainties. • Generate personally novel solutions related to flooding.
Other skills	Collaboration, Communication
Key words	Precipitation, cycles, systems, temperature, flood, engineered solutions, vapour, warming, modelling

Products and processes to assess

Students develop their collaborative, creative, modelling skills by conducting and sharing interviews, and constructing and using maps and conceptual and physical models to explain phenomena. At the highest levels, students show a willingness to carefully examine a variety of ideas, generate several unusual ideas and push some to their limits before making final choices. They show a clear understanding of the strengths and limitations of chosen approaches according to different criteria and an openness to the ideas and feedback of others.

Authors: Adah Miller, E., Codere, Severson, A., S. For PBL Science Connections. (2022) https://sites.google.com/view/pblsci/home. Modified for the OECD for the CERI project *Fostering and Assessing Creativity and Critical Thinking Skills* and edited by Cassie Hague (Analyst, OECD).

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
1	Lesson period 1	Introduce the Unit Driving Question (DQ) – which is the title above; tell students they will be learning about extreme weather and rain events, and why they are becoming more frequent. Have students consider the driving question and say or write initial thoughts to post on a shared DQ board (an area accessible to all students where they can post and arrange questions, comments and ideas related to the DQ). Ask them to think of as many words as they can related to extreme weather, and work with the class to create a definition of each word (e.g. drought, tornado, flash flood etc). Go for a walk around the school, observing where water is found and how it is contained; look for puddles, clouds, evidence of water underground and in plants etc. Prompt students to see evidence of water they may otherwise miss and to consider why there might be water in different locations at different times. Briefly introduce them to some of the properties of water (for example, you might say that it spreads out when there is nothing holding it such as a hole or an indentation, that its volume increases and density decreases when it freezes and that it dissolves many materials, such as some limestone). Back in the classroom, reintroduce the DQ and ask students to work in groups to generate questions to populate the DQ board. Ask students to also come up with questions that they think are different, unusual, or surprising. Each group should select their favourite questions for the class to consider and explain why they are their favourite (i.e. what criteria they have used to decide).	Vocabulary related to extreme weather. Observing and gathering information about water and weather. Properties of water. Locations of water.	Inquiring: Observing and describing relevant information. Imagining: Exploring extreme weather events and generating divergent and unusual questions.	Inquiring: Understanding the context, frame and boundaries of the problem.

2	Lesson period 2	Ask the students, “What knowledge do our families and community connections have about weather, rainfall, flooding, and drought?” Have students think about who they could interview to learn about some common ideas and different perspectives on rainfall, flooding, drought, and other water events. Have student plan the questions for the interviews they will conduct for homework (e.g., “Tell me about one or more events that happened in your life related to weather and water. What do you remember? What can you tell me about the land, water, and weather related to each event? In what year and place did they happen?”). Encourage students also to think of novel and unusual questions and to use the vocabulary discussed in step 1. Discuss with students the differences between facts, memories, opinions etc. Ask them to consider what sort of information they will be able to get from the interviews, how reliable it is and why, how they can use this information and what additional information sources they may need. Students complete interviews for homework.	Writing interview questions using water vocabulary. Differences between facts, memories, and opinions.	Imagining: Generating questions about experiences of rainfall, flooding and drought.	Inquiring: Posing interview questions to identify and question generally accepted ideas about extreme weather.
3	Lesson periods 3 and 4	Students share their interviews and pictures with the class. As students share, ask questions about what claims they can make on the basis of individual experiences, observations and memories and what gaps in knowledge still need to be filled. Probe thinking about how water in each event described in interviews is moving through systems. Then help students describe the event in terms of moving water and cycles (i.e., flood – large amount of water moved from the sky to the rivers and over riverbanks; hurricane: large amount of water moved from clouds to the ground with high winds). Plot each shared event on a timeline and ask students to identify were on the world map they took place. Distribute and explain a diagram of the water cycle and ask students to keep it in their notebooks for reference. Share some additional extreme weather events from newspapers or other sources, reminding students of the importance of thinking about how reliable	Describing and comparing water and water related events. The water cycle and water systems. Identifying places on a map of the world.		Inquiring: Identifying and questioning common ideas about weather events, becoming aware of gaps in knowledge, framing real life events in scientific terms.

		sources are and asking for their ideas for how to check the information presented. Work with the students to look for patterns (i.e., more water events recently, bigger events recently, or more extreme events; and that weather and water events happen in some places more than others). Ask students, “Are weather and water events the same or different in different places, or in different times in history?” “Do people have the same or different memories of them?” Highlight with the class that claims can differ even when based on similar evidence and investigation is important. Ask for their ideas of how to verify any patterns identified. Return to the DQ board and ask students to add any questions and identify any they feel have been answered.	Identifying and verifying patterns in data.		
4	Lesson periods 5 and 6	Tell the class they will be investigating how water moves around through air and ground to better understand some of the patterns they found. Ask if water is moving. Have each student group pour water on a paper towel or cloth material and then try to “dry” the paper or cloth. Identify what seems to be working to dry the materials and have students describe what happened to the water. Offer explanation of the evaporation of water molecules into the atmosphere as needed. Have students draw 1-2 models that show what happened to the water in the “drying” process. Share and discuss the models and any differences between them. Press students to connect ideas across experiences, for example, if one student waved their materials around to dry them, consider how this was similar or different to holding the material in the wind. Ask students to consider whether the air is “holding” water and make suggestions for how they might test this. Discuss the strengths and limitations of each proposition according to different criteria, including feasibility.	Water vapour, evaporation Investigating a scientific claim that water vapour is in the air.	Imagining: Generating and exploring, unusual ideas for experimental design.	Doing: Explaining strengths and limitations of experimental designs justified on different kinds of criteria
5	Lesson period 7	Implement the investigation for testing whether air is “holding” water planned in step 4. For example, you might show students a container that is completely sealed. Put warm water in the container. Observe the outside of	Condensation.		Inquiring and reflecting: Analyse gaps in knowledge

		the container. Now put ice in the container. Observe the sides of the container. Ask where the water that collects on the sides came from (from water vapour in the air). Work with the class to develop a model of condensation. Ask students to describe how the model shows a cloud, air, and rain system. Ask students to consider what they know and don't know about such systems and provide information as appropirate to fill in the gaps. Return to the DQ board to discuss questions and comments and add more.	Investigating a scientific claim that water vapour is in the air.		and reflect on remaining uncertainties regarding weather systems.
6	Lesson periods 8 and 9	Groups make two physical models of precipitation: in room temperature and in warmer temperature. Put clear plastic wrap on two identical clear glasses or plastic cups so that they are completely sealed and then place ice cubes on the outside top of the plastic wrap cover. Place one cup on a heating pad and the other on the table. Have students write predictions of what might happen in both cases and encourage them to identify what assumptions they are using to make their predictions. Students will see "raindrops" gathering and falling. The heated system will show bigger and faster "rain." Work with students to model the two systems. Demonstrate making a claim and supporting it with evidence that the warmer temperature caused bigger and faster "rain". Ask what this might mean for rain events if temperatures on Earth are rising? Prompt students to consider what they are assuming to be true and what they think is certain and uncertain about the connections they are making and why, making suggestions as necessary.	Models of precipitation. Effect of temperature on water vapour in air. Isolating variables.		Inquiring: Identifying and questioning assumptions about connections between rising temperatures and rain events.
7	Lesson period 10	Return to the timeline and map of weather and water events from the family interviews and other research. Ask, "Which might have been caused by warm weather and why?" Explain in more detail that links have been made between global warming and more frequent and more intense weather and water events, and present some evidence of these links. Ask students to use what they know about water vapour to explain in writing how these two factors might be related. Have students write their explanations in notebooks and then share and discuss as a class, making sure to prompt students to reflect on both patterns and any uncertainties or different possible perspectives on these relationships and how they could be interpreted.	Considering relationships between rising temperatures and more intense weather and water events		Reflecting: Evaluating and acknowledging the uncertainty or limits of models.

		Return a final time to the DQ board to check if all the students' questions have been answered.	Water vapour.		
8	Lesson periods 11 and 12	Student groups make a model of an engineered solution to one of the extreme events caused by more intense rainfall. Have each group cut a two-litre plastic bottle in half. Each half will have a layer of sand and soil that is packed. Students should use their index fingers to make a river. Tell each group you will spray (rain) a cup of water on the system. Demonstrate the resulting flood. Each group will need to design 1-3 solutions to contain the water, for example, by choosing and designing rocks as a barrier, placing uprooted plants around the river, developing another river branch or reservoir, or something else that students come up with (students should be asked to include one more unusual idea in their 'menu' of solutions). Small groups first brainstorm, discuss, and select an idea. Then, test the solutions and consider benefits, drawbacks, novelty, limits and possible alternatives to each solution (this can be done either in discussion or in written work). If time allows, students can revise one of their solutions in response to feedback or add some information about the limits of their solution to their model.	Constructing engineering solutions based on criteria and constraints.	Doing: Designing personally novel solutions. to contain water. Reflecting on the novelty of the solution and its possible consequences.	Reflecting: Reflecting on the chosen scientific solution and considering possible alternatives; Evaluating and acknowledging the uncertainty or limits or the solution.

Resources and examples for inspiration

Web and print

- Make precipitation https://www.youtube.com/watch?v=9kRkQ9tyq3U
- Video of a family in Flint, Michigan

Other

- Cut a door in the side of a 2 litre bottle for each small group or individual student. See diagram . A small fish tank with lid or clear plastic shoe box with lid could also be used for a larger model. Also see *video of model*.

Opportunities to adapt, extend, and enrich

- This mini-unit is based on portions of the two learning sets in a sequence of four learning sets. Remaining learning sets have students investigate where their drinking water comes from, the causes of pollution in the water they drink, drought, and PFAS, and engage in text and media to develop an understanding of community efforts to make their drinking water safe. They read texts about communities around the globe that solve problems in their communities related to water. They learn about the Flint water Crisis and a similar crisis in Detroit, Mi.. United States

- Remaining learning sets, along with additional STEM project-learning units and related resources can be found at https://sprocket.lucasedresearch.org/course/science4/fresh-water. 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. ML-PBL units are licensed under a Creative Commons Attribution-NonCommercial 4.0 International License and were funded by the George Lucas Educational Foundation.

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	1	Identify and question assumptions and generally accepted ideas of a scientific explanation or approach to a problem	1, 2, 3, 5, 6
IMAGINING	Generate and play with unusual and radical ideas when approaching or solving a scientific problem	1, 2, 4	Consider several perspectives on a scientific problem	6
DOING	Pose and propose how to solve a scientific problem in a personally novel way	8	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.)	4
REFLECTING	Reflect on steps taken to pose and solve a scientific problem	8	Reflect on the chosen scientific approach or solution relative to possible alternatives	5, 7, 8