Connecting Climate Change to the Science 10 Curriculum through Inquiry

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These inquiries intend to support students through building an understanding of the science of climate change. This learning takes place through inquiries stemming from questions generated by students, is authentic and meaningful. The ideal goal of an inquiry is to apply learning and take action.

These inquiries highlight instructional strategies that allow for students' perspectives and voice. The resources, activities, climate change data and information provide the groundwork to ultimately engage in action and environmental stewardship opportunities. Each inquiry is designed to stand alone, addressing different angles and lenses through which climate change can be explored. We do recommend beginning the learning with Inquiry 1 'What is Climate change and Why Care?'. This inquiry provides a good introduction to climate change and allows students to begin by thinking about the importance of this issue in their own lives and future.

Many of the curriculum outcomes of Grade 10 Science can be linked to understanding the phenomenon of climate change. Climate change learning spans across subject matter and is relevant to students.

Connecting climate change to the curriculum through inquiry

1. **What is Climate Change and Why Care?** - This inquiry focuses on the question: "What worries you about climate change?" Educators begin by asking students to identify actions that they have seen or heard of recently that inspire them about climate change reduction. This generates discussions focused on breaking down the emotional barriers of climate change education. We also suggest to frame learning pathways broadly by connecting to actions or local environmental stewardship projects that students identify as personally relevant and important to them.

Science 10 Curriculum connections for this inquiry

- *identify, investigate, and defend a course of action on a multi-perspective social issue (118-9, 215-4, 118-5)*
- *identify questions and analyze meteorological data for a given time span and predict future weather conditions, using appropriate technologies (214-10, 331-5, 212-1)*
- *describe how different geographical locations can sustain similar ecosystems (331-7, 318-3)*

2. **Monitoring Change: Using the Climate Atlas of Canada** - This inquiry focuses on the importance of monitoring change using the interactive website the Climate Atlas of Canada. This site will enable students to research past, present and future climate impacts in their communities under different emission pathways. From a psychological and educational standpoint, investigating climate change from a regional scale is preferred because 1) planning for and adapting to climate impacts is often undertaken at a city/municipal/community level, 2) students can engage directly with local experts and 3) this ensures learning is in alignment with the scale of jurisdictional response and in alignment with students' locus of control. After exploring climate change impact projects, students can develop environmental stewardship projects that focus on mitigating or adapting to climate risks.

Science 10 Curriculum connections for this inquiry:

- *use weather instruments effectively and accurately for collecting local weather data and collect and integrate weather data from regional and national weather observational networks (213-3, 213-6, 213-7),*
- *identify questions and analyze meteorological data for a given period and predict future weather conditions, using appropriate technologies (214-10, 331-5, 212-1)*
- *illustrate and display how science attempts to explain seasonal changes and variations in weather patterns for a given location (215-5)*
- *describe examples of Canadian contributions to weather forecasting and satellite imaging, showing how scientific knowledge evolves (117-10, 115-6)*

3. **Environmental Impacts & Restoration**- This inquiry delves deeper into the multifaceted environmental effects of climate change. We encourage students to harness their curiosity about the local environment by examining changes to the ecosystem, species at risk, large-scale environmental impacts, etc. or by connecting with a community expert and exploring restorative practices. We have included a multitude of external resources and guiding questions to help support and extend student research.

Science 10 Curriculum connections for this inquiry:

- *predict and analyze the impact of external factors on the sustainability of an ecosystem, using a variety of formats (212-4, 214-3, 331-6)*
- *diagnose and report the ecosystem's response to short-term stress and long-term change (213-7, 215-1, 318-4)*
- *identify, investigate, and defend a course of action on a multi-perspective social issue (118-9, 215-4, 118-5)*
- *describe how different geographical locations can sustain similar ecosystems (331-7, 318-3)*
- *identify questions and analyze meteorological data for a given time span and predict future weather conditions, using appropriate technologies (214-10, 331-5, 212-1)*

This resource highlights learning opportunities that engage students in choice. Choice and action help make the concept of climate change more relevant and meaningful to the student. In the culminating task, the students apply what they have learned in the inquiry to create an action plan for an environmental stewardship project of their choice. An environmental stewardship project aims to have students connect responsibility and choice and fosters the development of important competencies. The action plan meaningfully engages students throughout the process, from choosing an issue to how students will carry it out. The best way to showcase action is by getting involved in helping combat climate change.

What is climate change and why care?

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What is climate change and why care?

Adapted from LSF's Climatelearning.ca

BACKGROUND INFORMATION FOR EDUCATORS

Canada's climate is changing at an accelerated rate: since 1948 Canada's annual average land temperature has increased by 1.5°C—roughly double the global average level of warming (Natural Resources Canada). "Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems" (IPCC). It is true that there are many natural forces that play a role in determining the Earth's climate: the Earth's orbit around the sun, changing ocean currents, very large volcanic eruptions and the Earth's tilt, and there is a great deal of evidence that the world has warmed and cooled in decades before humans existed. However climate changes have never occurred at a pace as rapid or as drastic as we have seen since pre-industrial time, and these changes cannot be explained by any natural phenomena (Prairie Climate Centre). These changes are a cause for concern but, more importantly, they are also a call to action to mitigate current and future effects.

Some of the many impacts of climate change include: biodiversity loss, ecosystem changes/destruction, species loss, and extinction. If the global community is able to limit the increase in temperature to 1.5 degrees, the impacts on terrestrial, freshwater and coastal ecosystems are expected to be lower. According to the Council of Canadian Academies' expert panel on climate change risks and adaptation potential, Canada faces substantial risk with a likelihood of significant losses, damages, or disruptions in Canada over a 20 year timeframe in the following areas: agriculture and food; coastal communities; ecosystems; fisheries; forestry; geopolitical dynamics; governance and capacity; human health and wellness; Indigenous ways of life; northern communities; physical infrastructure; and water.

Overall, Canadians are quite certain that climate change is happening. According to a recent survey conducted by Dr. Ellen Field and Learning for a Sustainable Future, 85% of all Canadians believe that climate change is happening. However, the population is less certain that humans are the primary cause of the warming climate; only 43% of respondents think that climate change is caused mostly by human activity. When this understanding is contrasted with the widespread scientific consensus that climate change is human caused, the urgent need for more comprehensive education on the subject is made clear. In a thorough literature review, Cook and colleagues found that after examining 11,944 climate abstracts from 1991 to 2011, 97.1% endorsed the consensus position that humans are causing global warming.

Another finding from the report, Canada, Climate Change and Education: Opportunities for Public and Formal Education, found that 46% of students ages 12-18 are categorized as "aware," meaning they understand that human-caused climate change is happening, but they do not believe that human efforts to stop it will be effective. This is an opportunity for schools to help students understand that there are strategies and solutions to address climate change if all sectors take action today.

PROVOCATION

To hook student interest, watch one of these videos as a class or in small groups to initiate student thinking

A Ticking Clock: Lyme disease, climate change and public health [Climate Atlas] - 5:40 minutes
Lyme disease is on the rise in Canada, due in part to climate change. Warming temperatures are allowing blacklegged ticks – the species that carry Lyme disease in central and eastern Canada to move to new territories. Hear from the scientists, medical professional, and citizens on the front lines of this infectious disease issue, and how we can prepare and protect our families and communities from this risk.

New report warns of climate change risks for Canadian communities [The National] - 3:34 minutes
A news report done for the federal government highlights the top six areas of risk for Canadian communities.

My Cheeseburger Footprint [Margaret Sanchez] - 2:14 minutes
This video tracks the 10 pounds of carbon dioxide gas emitted from the production of a single cheeseburger.

One degree and Its Impacts What does climate change mean for Canada [Climate Atlas] 2:49 minutes
Climatologist Damon Matthews examines the evidence of our warming climate and what these changes mean for Canada. He describes how this change of one degree in just over 100 years is both human-caused and unparalleled in geologic history.

QUESTION GENERATION

Harness students' curiosity and build off of the provocations that have captured their interest by generating meaningful questions to continue to drive the learning process.

- What questions do you have after watching the video?
- What did you hear that surprised you? How do you feel after watching the video?
- How does this new information connect to what you already know about climate change?
- What are some common impacts of climate change in your community? How does climate change affect your life?
- How do the choices you make affect Earth's climate? Would they contribute to or lessen the effects of climate change, or would they have a neutral effect?
- What can we do to mitigate the impacts of climate change?

KNOWLEDGE BUILDING

At this stage, students may be ready to engage in a group knowledge-building activity.

De Bono's Six Thinking Hats will encourage students to open their minds to many alternative ways of thinking about the provocations and ideas generated thus far in the inquiry process. Each student will be assigned one of six different coloured "hats" and each thinking hat will indicate a different perspective or way of thinking about what climate change is and why it is important to care about this issue. This activity tends to be very effective when students are working in groups.

All types of hats are important for decision making and critical thinking and students should think carefully about how each viewpoint contributes to a deeper understanding of climate change.

For a more detailed description of these hats, and question examples, please see our Active Thinking Strategy Bank

The following chart provides a brief outline of what each coloured hat represents:

White	Information	Asking for information from others.
Black	Judgement	Explaining why something may not work.
Green	Creativity	Offering possibilities, ideas.
Red	Intuition	Explaining hunches, feelings, gut senses.
Yellow	Optimism	Being positive, enthusiastic, supportive.
Blue	Thinking	Using rationalism, logic, intellect.

There are several options for which question to choose to fuel this exercise: you could use one of the questions generated after the provocations, or you can take the freedom to focus in on a piece of information, perspective, or observation that the class was particularly drawn to thus far.

DETERMINING UNDERSTANDING

Uses responses to inform and guide the learning process.
Ask students to fill out the “Know” and “What”/’Want to know” columns of a K-W-L chart in relation to the questions. Use responses to inform and guide the learning process. They can provide insight into which concepts need clarity, what many students are already well informed about, and a general direction that many students want to pursue.

<u>Sample KWL chart:</u>

TOPIC:		
K – What I Already Know	**W** – What I Want to Know	**L** – What I Learned

PURSUING LEARNING: FOUNDATIONAL CLIMATE SCIENCE CONCEPTS

At this stage, students may begin research to pursue their questions generated earlier. The following learning experiences could be integrated into the process where helpful.

Activity 1 - What's the difference between weather and climate?

This learning experience is designed to provide clarity on the terms *weather* and *climate*. Through a hands-on activity (using beads) students will simulate documenting weather trends in a specific region over time. Students should understand, explain, and easily distinguish examples of weather vs. climate.

- Weather is a day-to-day state of the atmosphere, with short-term variation (minutes to weeks). It is what is happening when you look outside right now.
- Climate describes the range of what you might expect in a certain location at a general time of year. It describes the average and long-term weather trends.

In this interactive activity, each group of students will use beads of different colours and shapes
Each group of students will need a paper bag of beads of different colours and shapes. Each bag of beads will represent the weather in your local area for the month of April. Define a different type of weather for each colour of bead. Red might be cool and cloudy, blue hot and sunny, green for windy.

Ask each group to remove one bead from their bag without looking at the beads. That's the weather on April 1st. Now, ask each group what colour they picked from their bag. In some groups, the bead will be red (April 1st was cool and cloudy); in others, it's blue (April 1st was hot and sunny.) That's the weather.

Now, have each group place all their beads on a table and count: How many red beads? How many blue? You'll find some differences between groups, but the differences are reasonably small. Some groups may get a larger percentage of red beads, and others will get more blue beads. But no one will get all red or all blue!
If you look at the weather over a more extended period of time, patterns start to emerge. You are beginning to pin down the climate.

Now, calculate an average number for each colour in all of the bags. This represents climate, the average weather, and what you expect. If you give someone a new bag, you can't predict the weather—whether the next candy out of the bag will be blue or red—but you can predict trends in the weather. You can say, with confidence, that there won't be ten red candies in a row. That would be very unlikely! When you have completed the task, ask your students the question we started with: What is the difference between weather and climate? [Activity adapted from What's the difference between weather and climate]

Activity 2 – Climate Change – It's Not All Doom and Gloom

These learning experiences will introduce students to concepts pertaining to climate change, and allow them to explore the different affect climate change has on the Earth and our society. Students will discover the differences between weather and climate, and learn about carbon and its role in climate change.

Activity 3 – Carbon Dioxide Trends (access the activity page 19-23)

In this learning experience students will explore long-term atmospheric carbon dioxide trends over the past 45 years. They will predict future carbon dioxide emissions based on the graph as well as examine historical carbon dioxide data. After a discussion about the greenhouse effect and the human activities that contribute to it, students will work in pairs using climate data provided by Western Washington University to graph the data and note any trends that they observe. This resource provides discussion questions that address general correlations like carbon dioxide and time of year, predicting carbon dioxide levels in future years based on past data, and predicting activities that may speed or slow increasing levels.

Activity from Climate Change: Connections and Solutions*, Western Washington University (2013)*

CONSOLIDATION

This step is designed to encourage students to integrate and synthesize key ideas. When students make connections and see relationships within and across various learning experiences, this helps them to solidify knowledge and deepen understanding.

Journal reflection prompts – Have students reflect and write about

- This is why I care about climate change
- Reflect how you would explain (text or drawing) any of the following to a classmate, family member, or neighbour:
  - climate vs. weather
  - how the greenhouse effect works
  - carbon dioxide as a primary cause for climate change

Take Action - Environmental Stewardship

Allow time for students to take action is an essential part of the learning process on climate change, as it empowers students and eases their eco-anxiety.

Ideas for Taking Action

- Have students be environmental stewards in their communities. Have them educate their community about the risks posed by climate change
- Create posters that represent some of the local risks to your community
- Organize an assembly to present climate change risk information in an engaging manner
- Engage your students in a learning experience that is hands-on, real world, memorable and impactful. Learning for a Sustainable Future provides funding for student -led climate change/sustainability Action Project. Apply for a LSF grant
- CLEAN Climate Action Grants empower youth to design and execute climate action projects to create positive environmental change in their communities
- Our Canada Project inspires youth to be responsible citizens and gives them a platform to share their voices. Check out some of the latest projects from coast to coast

Environmental Impacts and Restoration

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BACKGROUND INFORMATION FOR EDUCATORS

Regions across Canada are already experiencing the effects of climate change. Many ecosystems are changing rapidly, and animals' habitats are changing at a faster rate than they can adapt. The Living Planet Report shows an average decline of 60% in animal populations between 1970 and 2014. In order to conceptualize some of the major environmental effects that can be attributed to climate change and trends that could emerge in coming years, the effects have been broken down into the following sub-categories: changes in temperature and precipitation, changes to the cryosphere (portions of Earth's surface where water is in solid
form, including ice caps, glaciers, sea ice, snow cover, etc.), changes to freshwater resources, changes to ocean climate, and biodiversity changes.

Changes in Temperature and Precipitation:

- In Canada, temperatures have increased by 1.5 degrees above pre-industrial levels. Canada's position in the far northern hemisphere means that we are experiencing the effects of climate change at a higher rate than many other regions in the world.
- Warmer air has the potential to absorb more surface water, resulting in both droughts and more intense precipitation events. Overall trends indicate that Canada has become wetter in the past decade, with increased rainfall and decreased snowfall across many regions of southern Canada.
- Temperature and weather extremes are expected (very hot and very cold as well as very wet and very dry) leading to a higher risk of associated environmental hazards such as floods and droughts.
- Overall temperature warming is enhanced in the northern latitudes of the country

Changes to the Cryosphere

- Permafrost temperatures in Northern Canada have been fairly consistently rising 0.2 degrees per decade over the past 20-30 years
    - Globally between 2007 and 2016, there has been an average increase of 0.29°C ± 0.12°C in permafrost temperatures (IPCC, 2019)
    - The effects of melting permafrost include release of harmful greenhouse gases previously trapped within the ice and reduction of structural support in regions previously covered by permafrost
- Glaciers have been melting at an accelerated rate since the beginning of the 20th century—glaciers lost 11% and 25% of their surface area in Alberta and British Columbia, respectively, between 1985 and 2005.

Changes to Freshwater Resources

- Changes to freshwater resources across Canada are difficult to categorize as a whole, nationally, due to the extreme regional variation that exists
- Canadian data shows that water quality has remained stable in the vast majority of monitoring stations across the country (81%) between 2002 and 2016, improved in 10% of locations, and decreased in 9%.
- However, the levels of PBDEs (Polybrominated diphenyl ethers, persistent organic pollutants) remain above prescribed guidelines in the following locations: The Great Lakes, Pacific Coastal, St. Lawrence.
- Excessive nutrients in both the Winnipeg River Basin and The Great Lakes area have caused detrimental algae blooms in these locations

Changes in the Ocean Climate

- Trends in the Pacific, Atlantic and Arctic oceans indicate long-term warming of approximately 0.1 percent per decade, both surface temperatures and bottom waters
- Ocean temperature, acidity, and oxygen levels are affected by increasing atmospheric carbon dioxide levels
    - Since the 1980's the ocean has absorbed between 20-30% of total anthropogenic carbon dioxide emissions
- The rate of ocean warming has more than doubled since 1993 (IPCC).
- Ocean levels are rising at a concerningly fast rate (in part due to the melting ice caps), which is increasing the risks of flooding and potential contamination of freshwater and groundwater, among other issues
    - In Canada, a country surrounded by three different ocean bodies, the changes to ocean levels, temperature and composition are of paramount importance

Biodiversity **changes in Canada:**

- Increases in the frequency and intensity of droughts, forest fires, and insect outbreaks in combination with direct human impacts like deforestation, pollution and overharvesting are resulting in habitat loss and threatening the survival of many species (Canada and a Changing Climate).
- Changes to season lengths and times (such as earlier springs) are changing the growth and reproduction patterns of many plant species, which directly affects animals that rely on them for food and habitat
- Physical changes in the landscape (e.g. higher water levels or human barriers such as roads, farms, and dams) can prevent animals from accessing food or breading/rearing areas

PROVOCATION

To hook student interest, complete the learning experiences as a class to initiate student thinking

Idea 1 - Picture prompts

Images can provoke strong responses. Find some topical photos and ask students "What do you think this image is saying?" A few suggestions are listed below. (For more ideas on how to use them, go to the New York Times resource on How to use Picture Prompts.)

Click on the links below to access the following picture prompts

- Falling Bottles
- In Your Head
- Student Climate Strikes

Idea 2 – Video – Storms of the Future
After a 1-100 year storm flooded Truro, Nova Scotia under five feet of water, the conversation around town shifted to questions about the future. What's clear to local residents is that climate change is bringing higher tides, stronger winds and flooding, leaving more and more people shouldering the costs and risks.

Idea 3 – Neighbourhood Walk
Go for a walk around your school yard or neighbourhood and ask students to identify natural, human and built systems that impact climate change. Notice the diversity of species in your neighbourhood. Are there areas that are more diverse than others? Why do you think this is the case? How can we improve/promote healthy habitats through increased biodiversity?

Discuss how climate change is affecting or may affect the environment in your local area. Have students document their observations through photos, sketches and notes. After the walk have students reflect on their observations and discuss how their everyday actions can impact climate change.

QUESTION GENERATION

Harness students' curiosity and build off of the provocations that have captured their interest by generating meaningful questions to continue to drive the learning process.

Using the "Question Formulation Technique (QFT)"

Reflecting back on their neighbourhood walk, ask students in groups to generate as many questions as they can in the allotted time (suggested 5 min). To generate questions, follow QFT rules for producing questions:

- Ask as many questions as you can
- Do not stop to answer, judge or to discuss the questions
- Write down every question exactly as it is stated
- Change any statement into a question

Review the difference between open-ended and closed-ended questions and ask students in groups to identify open questions with an "O" and closed questions with a "C". Ask students to rewrite three closed-ended questions into open-ended questions and three open-ended questions into closed-ended questions.

Prioritize questions

Next, ask students to review their questions and prioritize them according to which ones they believe will help the class better understand how local natural systems are being affected by climate change.

KNOWLEDGE BUILDING

At this stage, students may be ready to engage in a group knowledge-building activity.

Invite a speaker

Invite a local community expert to learn about local climate impacts and local climate action responses.

Places to look for a local community expert:

- Naturalist groups
- Climate adaptation representative (municipal, provincial)
- Department of Natural Resources and renewables
- Conservation Authority/Agency
- Conservation NGO

Students can have the questions they generated on hand to prompt them to ask the speaker.

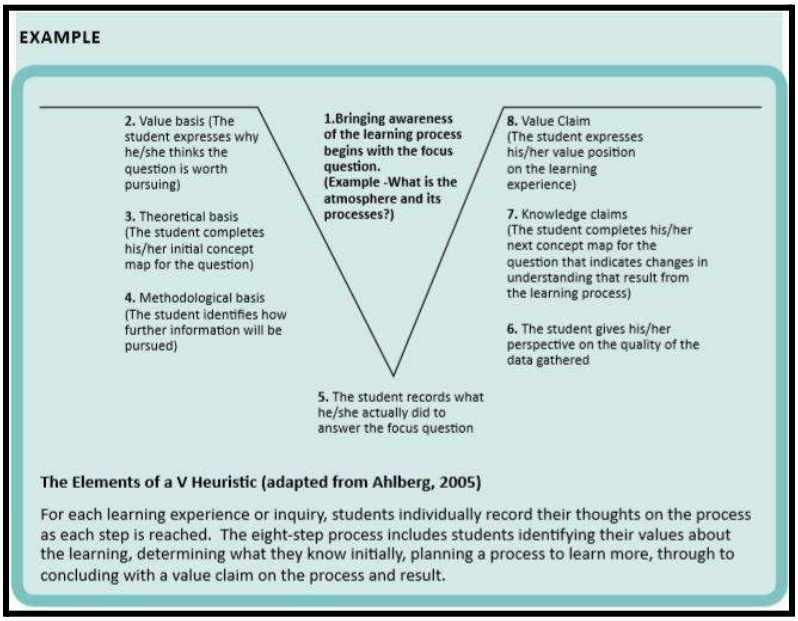
DETERMINING UNDERSTANDING

Uses responses to inform and guide the learning process.

V-heuristic

After hearing from a guest speaker, have students review their questions, make notes about what they've learned and develop any new questions.

Then ask students to select one question as a top priority. Working with this question, students will each go through the v-heuristic process steps 2-4. These steps will help students focus on how and where to direct their learning.



PURSUING LEARNING: FOUNDATIONAL CLIMATE SCIENCE CONCEPTS

At this stage, students may begin research to pursue their questions generated earlier. The following learning experiences could be integrated into the process where helpful.

Individual or group research

At this point, students can individually pursue their own research process, or you can facilitate students working in groups as they begin to conduct research.

How is climate change impacting our community??

- Climate Atlas of Canada
- An Overview of Canada's Changing Climate; in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation

How are species most at risk in our area? What factors contribute to their risk?

- Government of Canada's Species at Risk Public Registry
- Biodiversity and Protected Areas; in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation p. 159-190

How are we all connected? How do the environmental impacts across the country affect us in our community?

- Climate Atlas of Canada
- An Overview of Canada's Changing Climate; in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation

How are some high-risk areas implementing adaptation strategies to reduce environmental impact? (Example: flooding or droughts)?

- Federation of Canadian Municipalities Resource Database (2019)
  *Search for local municipal examples among 49 case studies from Canadian municipalities
- Government of Canada's Long Term Infrastructure Plan (2018). [See Green Infrastructure section]

How are some areas effectively using restoration actions to mitigate climate impacts?

- Examining the viability of planting trees to help mitigate climate change. NASA
- 5 things to know about fighting climate change by planting trees. *Science News*.
- To Ensure a Stable Planet, 30% of the Earth needs protection by 2030. *National Geographic.*

CONSOLIDATION

This step is designed to encourage students to integrate and synthesize key ideas. When students make connections and see relationships within and across various learning experiences, this helps them to solidify knowledge and deepen understanding.

After students have had an opportunity to do some extensive research, a valuable consolidation tool to conceptualize and organize large amounts of information is a reverse mind map. Students can complete a reverse mind map in a group with other students who have chosen to address a similar topic. By combining all of the research that students did, information can be consolidated and hopefully some clarity will begin to arise.

Take Action - Environmental Stewardship

Allow time for students to take action is an essential part of the learning process on climate change, as it empowers students and eases their eco-anxiety.

Ideas for Taking Action

- Have students be environmental stewards in their communities.

- Plant trees/Habitat restoration
- Collect data as citizen scientist
- Support policies that improve environmental conservation and climate
- Join student council, municipal youth committee, or youth advisory board of a non-governmental organization
- Innovate sustainable solutions for school or community questions and problems
- Share your learning within your school and share your learning outside the class
- Engage your students in a learning experience that is hands-on, real world, memorable and impactful. Learning for a Sustainable Future provides funding for student -led climate change/sustainability Action Project. Apply for a LSF grant
- CLEAN Climate Action Grants empower youth to design and execute climate action projects to create positive environmental change in their communities
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Monitoring Change: Using the Climate Atlas of Canada

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BACKGROUND INFORMATION FOR EDUCATORS

Monitoring change is an integral part of each theme discussed throughout this guide. Changes are happening faster than we can track when it comes to climate, climate science, impacts on human health, policy, regulations and technology. Therefore, the central theme of this inquiry is empowering your students with the tools and skills necessary to conduct accurate and relevant research in order to effectively monitor the changing climate and changing world around them.

In Canada, mitigation of anthropogenic climate change and global warming is being addressed more seriously than ever before. In the 2015 election, the federal leadership made climate change a top priority and pledged actions based on the best scientific evidence and advice.
Using recent advancements in technology such as GIS and satellite monitoring, scientists can track climate change. This also allows scientists to narrow in and see the current and projected trends in specific areas and how these will affect our day-to-day lives.

Note: How to Navigate Climate Atlas of Canada: See handout here

Within this inquiry, students will become very familiar with the Climate Atlas of Canada. Up until recently, it has been difficult to find student-friendly websites and modelling tools to show the effects of climate change across all categories (rainfall, temperature, growing season, etc.) over time. By allowing students to focus locally and continuing to foster that connection, they can bring the issue of climate change closer to home before looking into specific effects in the upcoming inquiries. Often, it is only when we see the statistics or numbers to support certain claims that we truly see the reality of an issue.

With the Climate Atlas allowing students to look at “More or Less” Climate Change (more or less carbon emissions), they can see the results visually on a map or by looking at the data, making the issue more real than ever before. After using the Climate Atlas Map and recording the climate variables and discussing their findings, in groups, students are asked to graph the top variables to be put on display for the school to share the impacts in an engaging way.

To finish the inquiry and to continue moving forward in partnership with the community, a class trip to a local conservation area is encouraged to allow students to:

> see how local groups are monitoring the effects and trends of climate change
> see their concerns with the patterns they have noticed and
> have an opportunity to use some of the sampling apparatus themselves and contribute to data collection initiatives

References:
Climate Atlas of Canada. (2019).

PROVOCATION

To hook student interest, watch one of these videos as a class to initiate student thinking

Mapping and Modeling Change

The following videos from the Climate Atlas of Canada can be used to hook students' interest. They give students an opportunity to begin connecting how climate monitoring can not only give us useful information about local climate trends and predictions, but how we can use that information to our benefit. It also allows them to see the extreme effects that will take place if we do not act now and alter our lifestyles to keep our global temperature increase below 1.5 degrees Celsius.

Inuit Observations on Climate Change [Climate Atlas Canada]: 42 minutes
This video documents the impacts of climate change from an Inuvialuit perspective. The residents of Sachs Harbour have witnessed dramatic changes to their landscape and their way of life. Exotic insects, fish and birds have arrived; the sea ice is thinner and farther from the community, carrying with it the seals upon which the people depend for food. Thunder and lightning have been seen for the first time.

Dendroclimatology and the Canadian Prairies [Climate Atlas Canada]: 4:39 minutes
Dave Sauchyn is a dendroclimatologist who studies tree rings to learn about climate trends in history and what that might mean looking forward. His research shows that climate change is increasing the risk of droughts that are both severe and for extended periods of time, creating somewhat of a "new normal" for the Canadian prairies.

Roy McLaren, Lifetime farmer observing changes to farming industry [Climate Atlas Canada]: 4:30 minutes
Roy McLaren has farmed in southwest Manitoba for most of his life. In this video he is concerned looking at maps of climate projections. "That is pretty bad," he says, looking at maps showing a huge increase in very hot weather. "With that kind of heat," McLaren muses, "we'd have to change our farming methods. We'd have to adopt new crops."

QUESTION GENERATION

Harness students' curiosity and build off of the provocations that have captured their interest by generating meaningful questions to continue to drive the learning process.

Use the Bloom's Taxonomy – Question Starters to generate higher order thinking questions. As a group or individually, students can generate their own questions using the prompts for each of the six Bloom's Taxonomy levels: remembering, understanding, applying, analyzing, evaluating, creating. To access a pdf of the question starters click this link

Here are some sample questions to guide this inquiry using the six categories:

Remembering:

- Have you been able to see the impacts of climate change in your lifetime, specifically with the weather and climate patterns and trends?

Understanding:

- How can climate modelling help us at a local level?

Applying:

- How would you change the way we currently hear about climate change in the media?

Analyzing:

- Why should we rely on climate modelling?

Evaluating:

- How can we determine which climate monitoring tools are most reliable/accurate?

Creating:

- How would you generate a plan to mobilize the knowledge you learned so that others can benefit?

Resources for information on climate modelling in Canada:

- Modelling Future Climate Change Chapter 3 from Canada's Changing Climate Report provides an in-depth overview of climate modelling processes.
- Climate Change Projections: how computer models help us understand climate.
- The Government of Canada monitors changes through a program called the Climate Trends and Variations Bulletin.

KNOWLEDGE BUILDING

At this stage, students may be ready to engage in a group knowledge-building activity.

Carousel Brainstorm

Engage in a brainstorm and create a list examining how "Climate Modelling" is helpful for monitoring change. This can include different sectors that are or will be impacted and how to prioritize adaptation planning based on these shifts. You can do a whole class brainstorm if time is an issue, but to encourage active participation from all students, you can use a Carousel Brainstorm technique that includes movement, discussion and reflection.

With this strategy the teacher posts 4–5 large sheets of chart paper around the room, each with a different question or statement on how "Climate Modelling" is helpful for monitoring change. Students work in small groups and move from one station to another together, adding responses to each chart paper as they go. In the end, the class will have generated a list of ideas for each topic, that can be further discussed.

Examples of questions/statements:

- How do different climate models compare?
- How does climate modelling aid in our understanding of climate change?
- How can climate date, modelling and projections help us understand and prepare for the future?
- How accurate are climate models? How well have climate models predicted global warming?

DETERMINING UNDERSTANDING

Use responses of simple statements to inform and guide the learning process.

Ask students to reflect on their current understanding of climate change, climate modelling, and the importance of data tracking and monitoring changes as it pertains to climate change by using three simple statements to answer some or any of the guiding questions.

- *I was thinking…*
- *I've noticed…*
- *I've heard…*

These simple statements can be kept in a journal to refer to as the inquiry and learning progress, or students can share with a partner or group to provoke a thoughtful discussion. Teachers should take an opportunity to read students' thoughts to gain insight into student understanding.

PURSUING LEARNING: FOUNDATIONAL CLIMATE SCIENCE CONCEPTS

At this stage, students may begin research to pursue their questions. The following learning experiences could be integrated into the process to ensure that students understand foundational climate science.

The following learning experiences are designed to structure and guide students as they pursue learning within the Climate Atlas and gain skills and knowledge as it pertains to monitoring changes to the climate.

- Climate Atlas Open Exploration
- Mapping and graphing local data

Activity 1: Climate Atlas Open Exploration
With the Climate Atlas, students will have the opportunity to explore a variety of scenarios. You can model for your students how to examine *different variables* (such as very hot days >30℃, tropical nights, cold weather, precipitation, or agriculture), through various *emission pathways* (i.e. different predictions for the concentration of GHGs in the atmosphere over time), and at *different time periods* (recent past, 2021-2050, 2051-2080). Through the "find local data" section of the website, all these variable options

are available. Give students a fair amount of time to really dive into the website and test several combined variables and scenarios. Ask students to take a few minutes to examine the region that your school is located, but ultimately, students can focus on any geographic region that is meaningful or of interest to them.

This guidebook provides an overview on the basics of using the Climate Atlas, using the map, downloading local data, and interpreting climate data.

Students can organize data into an infographic by choosing three variables and looking at changes over two emission scenarios. Here is a student example:

After exploring the Climate Atlas, students will recognize immediately that the effects of climate change are not the same across the country or even across one province. You may want to debrief with your students by asking consolidating questions like: *Do the findings from the Climate Atlas make you think about where you want to live? Are you surprised which areas are more greatly impacted? Why or why not?*

Check here for student worksheets to guide them through exploring the Climate Atlas

Activity 2: Mapping and graphing local data

Students can visually represent some of the research that they conducted in Activity 1 on a map or a graph. Students can break into smaller groups (2-3 students) and discuss which information they want to collectively graph. The visualization should depict climate change impacts on your community. Groups can be encouraged to focus on diverse variables. The graph should include three time periods (recent past, 2021-2050, 2051-2080) and examine what would happen with "increased climate change" or "mitigated climate change."

Note: To assist with data visualization you can view information on the page "find local data" as a time series, frequency plot, scatterplot, or climograph. Data can also be downloaded into a .csv file to use for the data management or probability explorations.

Share your results with your school

From here, students can share their findings with the rest of their school community by putting these climate graphs on display. Students should be prepared to explain "why care." This is something brief that can be included on the poster to further spark a conversation for students or staff walking by.

Extension: Invite your community to engage with the maps.

- The class could include an interactive piece where students walking by can ask questions on sticky notes and post them on data that they are curious about.
- Have "emoji like reactions beside the maps for the school community to choose to indicate how this data makes them feel. Allow other students, teachers and staff to post their reaction to the maps.

Include instructions for your community on the wall or make an announcement in the morning to draw attention and invite interaction.

CONSOLIDATION

This step is designed to encourage students to integrate and synthesize key ideas. When students make connections and see relationships within and across lessons, this helps them to solidify knowledge and deepen understanding.

After using the Climate Atlas Map and recording the climate variables and discussing, allow students to turn to a partner and then "Think, Pair, Square". Give students a few minutes to think about the following questions on their own, then share their thoughts with a partner, and finally group with another pair to share as a group of four.

1. What surprised you most about the Climate Atlas Investigation?
2. What questions do you still have?
3. What concerns you most about where our school community is?
4. Why is climate monitoring so important?

Take Action - Environmental Stewardship

Allow time for students to take action is an essential part of the learning process on climate change, as it empowers students and eases their eco-anxiety.

Ideas for Taking Action - Making Connections – Moving Beyond School to Community Integration:
To complete the inquiry and continue moving forward in partnership with the community, a class trip to a local conservation area can extend engagement with students' sense of place. Depending on the conservation areas near the school community and the educational opportunities they provide, students are able to explore techniques and monitoring practices.

A hands-on opportunity would be to have students participate in some of the sampling practices themselves, to further understand the time and precision involved in keeping track of local changes. Lastly, this is a way to create a bridge between future careers and jobs within the field of climate change and environmental conservation.

Ideas for Taking Action:

Citizen Science - Conduct an ongoing experiment to track local changes in a specific aspect of the environment. Monitoring local changes can create a vivid first-hand account of the effect that climate change is having on the surrounding environment so close to home. This can reinforce the research that has been conducted through the Climate Atlas and provide new insights to inform action.

- Support Policies that support sustainability and climate change mitigation strategies - Research and understand current government policies and then take action by getting in touch with local government officials. For instance: write letters to local MP's voicing concerns about environmental policies and help students learn the importance of civic action; present Climate Atlas graphs and presentations to the local council.

- Engage your students in a learning experience that is hands-on, real world, memorable and impact. Learning for a Sustainable Future provides funding for student -led climate change/sustainability Action Project. Apply for a LSF grant
- CLEAN Climate Action Grants empower youth to design and execute climate action projects to create positive environmental change in their communities
- Our Canada Project inspires youth to be responsible citizens and gives them a platform to share their voices. Check out some of the latest projects from coast to coast