Planning Learning Experiences Around Climate Change, Regeneration, and Resilience

Teaching about climate change is like putting together a puzzle—there are so many pieces. But unlike most puzzles, there isn't a right way to arrange the pieces and more often than not, you'll have to decide which ones to include and which to set aside. One thing is certain, we need to design *coherent trajectories* of high-quality experiences for students that empower them to make sense of climate issues and expand their critical consciousness about what's happening to the Earth.

Much of this can happen in our schools, where educators have children for a full academic year, each year, from early elementary through high school. Informal and non-formal settings also offer unique opportunities for learning, and practitioners there can use many of the same planning principles described in this guide.

To start us off, I describe three scenarios, ranging from a small initial step in the right direction (designing a single unit), to one that coordinates climate-related learning across multiple years (in an elementary middle school, or high school). All three scenarios hold promise for fostering students' deep understanding:

- *A single unit—the nice first step*

  This refers to planning for a series of connected lessons, taught in the context of a typical science course (chem, physics, earth sciences, biology, interdisciplinary) or in an informal education setting.

- *An immersion course—charting new territory*

  This refers to planning a year-long course devoted to climate change phenomena. The course can be interdisciplinary (multiple areas of science or integrated with other subjects like social studies or language arts). It could also focus on a single science area like chemistry or biology. Each unit could address different facets of climate change events, human impact, R&R (regeneration and resilience), and social justice.

- *Coordinating student learning across grades—the most transformational plan*

  This is the design of a multi-year sequence of learning experiences in K-5, 6-8, or 9-12, that addresses climate change phenomena of varying types and scales, human impact, and solutions.

Let's start by identifying the challenges that climate-related teaching presents. Acknowledging these can help you design more effective learning experiences at any grain size. 1) All science phenomena or problems connected to the climate crisis will always have social, economic and political dimensions that make inquiry more authentic, but also more complicated. 2) We have to consider issues of scale, both temporal and spatial, when selecting a focus of inquiry (local versus global issues for example), understanding the processes involved or proposing R&R strategies. 3) Attending to students emotions like climate anxiety or eco-grief is essential, something we were never trained to do. 4) We have to incorporate various student perspectives, opinions, and worldviews into our lessons as they deliberate with one another about the meaning of climate change and it's impacts on different human communities.

What should be part of most individual lessons?

Before we get into the design of units, let's lay out what should be incorporated into most individual lessons. Lessons have to fit into an existing storyline or curricular "arc"—meaning that they have to build on what came before them and act as supports for lessons that follow. The good news is that existing lessons can easily be modified by adding learning opportunities that might be missing. No lesson will have all the qualities listed below but don't discard a lesson because it only meets "most, but not all" of the criteria here.

1. Clear objectives: Each lesson has clear objectives, made explicit to students, for improving some ideas or explanations for phenomena, or contributing to the solution of a problem. Sometimes the focus of a lesson is to understand and apply a concept like feedback loops or the carbon cycle. All lesson activities have to directly support your objectives.

2. Framing: Framing by the teacher at the start of the lesson helps students 1) understand how the ideas in this lesson is connected to ideas being worked on from previous lessons, 2) what puzzles students may be able to figure out today, 3) clear expectations for the intellectual work they will do today. Note that this is not just giving instructions or a warm-up activity.

3. An asset-based approach: Students' ideas, everyday experiences and family or community-based knowledge are elicited and used as resources to support knowledge-building by the class. Teachers respond to specific ideas from an asset-based perspective, allowing them to recognize the richness in students' reasoning and to support students to refine their ideas in a constructive and respectful manner.

4. Science practices: Students are allowed to engage in scientific practices (modeling, analyzing data, arguing with evidence, designing investigations, etc.) that further their thinking about important science ideas or solutions, including the uncertainty that goes along with these.

5. Scaffolding complex tasks: You provide scaffolds, as needed, to support students' reading, writing, speaking, or participation in intellectual work—students are not just given a task and told "get to it."

6. Epistemic agency: Students are given opportunities to exercise epistemic agency— that is, to make and defend claims, to decide what information and resources they still need to advance their thinking, to frame problems for themselves.

7. Sense-making opportunities: You build ample time into lessons for sense-making talk through small group and/or whole group discussion about data, phenomena, or potential R&R strategies.

8. Students show what they know: Students are given latitude to express what they know through different modalities such as the spoken word, writing, drawing, modeling. Creative expressions via art, zines, dance, role-playing, science theater, poetry, infographics and others may be powerful and encourage more students to participate.

9. Formative assessment: Formative assessments are used to guide further instruction based on what students know or are confused about. These assessments can include class dialogue, entry tasks, student work on models, exit tickets, and others modes of information. In some cases, formative assessments can be used to give students feedback on their thinking.

What phenomena or issues can a climate-related unit be based on?

Units can be based on climate change events, sustainability, solutions, or a mix of these. They can also include the history of how some humans have exploited or sustained the Earth's resources, and the worldviews different communities have about their obligations to the Earth—it all matters. Because all these issues are interwoven with the science, nearly every unit would explore each of them with varying degrees of emphasis, depending on the topic.

Some climate change topics are scientific phenomena or made up of multiple, linked scientific events and processes. Examples include the greenhouse effect, positive feedback loops in the environment, ocean acidification, amplified weather extremes, carbon cycling, and others. These geo-physical processes always have cascading effects on biological systems that include how species adapt to a changing environment, are forced into new habitats, or alter their behaviors in time (e.g. blooming, pollination, migration, mating).

On a larger scale, entire ecosystems might be transformed (Amazon rain forests shifting to dry savannah) or full collapse (some coral reefs). Regardless of whether the phenomena are geo-physical or biological, we can often find specific local or global examples of these events that students will find compelling. This encourages them to seek answers for how and why these events happen and with what consequences. We should remember that the explanations for why these happen will always have two layers. One is a natural science storyline, and the other is about choices that humans have made in the past, and continue to make, that put certain communities—sometimes all of us—at risk.

Some phenomena are combinations of cultural, logistical, and environmental challenges. A few of these have a clear science phenomenon associated with them; for example illegal deforestation is linked to ecosystem fragmentation, urban heat islands are linked to temperature extremes and redlining discrimination. In other cases we need to do some work to uncover the science concepts, as with food waste and fast fashion. We present a case of tracking down the science for events like these in the next section.

In addition to natural sciences phenomena, we need to address solutions such as different kinds of mitigation or adaptation. These include moving towards renewable energy, land reforms, dietary changes, restoring rights for Indigenous peoples to manage land, urban restructuring, etc. We can ask students how and why these strategies make natural systems more sustainable or help human communities and the more-than-human parts of the world become more resilient—at least for the time being. Students can explore the inevitable trade-offs when we consider transitions to a more sustainable world. How will we equitably distribute risks and benefits? What economic commitments are needed? How will we change how we live? These conversations can influence how students view themselves and their role in the community.

After you select a topic—what next?

Selecting a unit topic seems straightforward, but the next steps can get complicated. When I was planning with a group of secondary educators and university faculty from around the country, we landed on food waste as our focus for a 4-week unit. This came about because teachers in one of the high schools mentioned that their students were complaining about being served rice too often at lunch and throwing it away. We got excited that we could locate this phenomenon in school cafeterias and make it meaningful.

Our initial planning discussions generated lots of ideas and some confusion, but we expected ambiguity in this process. Members of our team suggested that students could collect data on food waste as well as examine second hand data on the GHG (greenhouse gas) emissions that rice, as a cultivated food, was responsible for. Members of the planning team brought up social justice issues in terms of carbon footprints related to adolescents' diets in the US compared with adolescents in other countries around the world.

While this was a promising start, we soon discovered that food waste was perhaps *not* the central phenomenon. We realized that rice and all the other kinds of food served in schools are part of a larger food system, which includes the resources to grow it, harvest it, process it, package it, transport it, and then prepare it for consumption on site. In light of this, our waste focus seemed too narrow. We had to look at how the whole system could be changed. That brought another challenge. When we found data on the GHGs rice and other crops were responsible for, there was also data available on how much water was needed to grow these crops and how much their cultivation disturbed the land. It turns out that the problematic footprint of rice (and wheat) is more strongly reflected in their water use and disturbed land area than in GHG emissions.

We wondered, should we expand our focus from the energy intensiveness of rice production and consumption to its full environmental impact? To complicate things further, we downloaded the state requirements for nutritional foods served in schools. These policies would preclude some student-generated solutions for curbing food waste in their own schools (for example offering less energy-intensive foods that were less healthy). This made us realize that "solutions" was the wrong word for what we wanted students to generate. Every possible move towards lowering waste involved multiple trade-offs—some in terms of cost, others in terms of nutritional substitutes for rice and others dealing with cultural norms for eating certain foods as well as eating everything you are served. The resulting four-week unit addressed most of the ideas described above and is now being tested out in classrooms.

What are our unit goals for students?

Whatever your level of ambition here, you'll want to identify the science standards that you could address. In doing this, remember that some standards speak directly to climate change, others to human impacts on the environment, and still others to designing adaptations or mitigations. But this is just a start.

Students should be able to frame problems to investigate so that they can begin to propose solutions. In the process, students should be able to identify and leverage the assets (cultural and scientific knowledge that exists within the local community), concerns, histories and hopes of a community and those of their peers. This is epistemic agency. We want students then, to take actions that help communities understand the causes/local impacts of climate change, mitigate them, or allow them to adapt to climate-related impacts.

We also want students to construct arguments about specific environmental injustices using the evidence of: (a) how climate events disproportionately impact some groups of people in negative ways, (b) how human action or inaction related to the environment can exacerbate environmental impacts on specific communities, and (c) recognize historical forces that continue to marginalize some groups of people and make them vulnerable to climate-related risks.

There are no planning frameworks that are perfect for all teams of educators. I do suggest, however, that early on you ask some version of the questions below—they will prompt you to consider how to achieve the goals listed above:

- **Local, real-word phenomena**: How might we focus on real-world phenomena that could be understood most deeply if at least a version of it, a part of it, is situated in a local context?
- **Involvement of community**: Where might there be opportunities for involvement of community members and to attend to voices that are often marginalized?
- **Include expansive worldviews**: How can we explore Indigenous worldviews that offer generative conceptions of humans' ecological roles in relation to the land, air, and water; and to weave together Indigenous knowledge and Western science in solving problems?
- **Help students use science practices as epistemic tools**: How do we involve students in in systems thinking, the interpretation of complex data, modeling, issues of scale, stability and change, cause and effect? This disciplinary work includes addressing the uncertainties that come with making claims about complex phenomena or solutions and supporting them with evidence.
- **A 360^{O} consideration of solutions**: Where could we address some of the social, cultural, historical and economic dimensions of regeneration & resilience strategies? You probably cannot address all of these in a unit. You need to do a bit of outside reading for this.
- **Attending to eco-anxieties**: How can we foster students' emotional resilience while helping them develop visions of desirable and socially just futures?
- **Agency & activism**: How can we foster a sense of agency in students by engaging them in activism and advocacy around environmental justice?

Addressing this list of questions for a unit may seem daunting, but it is a place to start. Not all the goals above have to be addressed in every unit. If, for example, you are collaborating with peers on a year-long interdisciplinary course at the high school level, these individual goals can be strategically addressed at different times throughout the school year. At this point you may want to do some reading with your peers about the science, how climate change data is gathered and used, solutions, the emotions involved in doing this work. Sharing the load can help your team recognize which topics hold the most promise and which might be rabbit holes.

Building in unit coherence from the students' point of view

Once you have your goals in mind and you start thinking about the long view of the unit, coherence becomes really important. Coherence between lessons helps students' sense-making and motivation, it makes your unit more than isolated lessons "in boxes." We don't mean coherence from *your* perspective, we mean from the *students'* view. Coherence from the student perspective is supported when a classroom community does the following:

- Students develop ideas over time, motivated by questions about phenomena, where each step is an attempt to address a question or gap in their current explanations and models. The sequence culminates when students put pieces together. They might do this by assembling elements of a model, an explanation, or a design solution developed across the unit.
- Students are asked to do sense-making through the use of scientific practices and finding links among science ideas. These help them make progress on the questions they are trying to figure out or problems they are trying to solve.
- Students engage in investigations in which they become partners in managing their own knowledge building. To support this, lessons feature ongoing reflection and discussions where teachers and students evaluate their progress and determine next steps.

Planning a year-long course

Here's an example of how a group of teachers co-planned a year-long interdisciplinary climate change & solutions course. The problem they addressed is: How do we arrange students' opportunities to engage with many ideas in a systematic and cumulative way, without overlooking important learning experiences? They also realized that different units would provide unique opportunities to address issues like emotions, uncertainty in data, and involvement with the local community.

> Despite all the guidelines mentioned here, this kind of planning is messy, not a linear or well-defined process. It's about considering multiple criteria at the same time, which can be challenging for a lot of us who really like structure.

What were the "starter" considerations? These teachers had to determine what their students already been exposed to, in the way of climate change experiences. Based on what students had learned in previous grades, they put on the table fundamental science concepts related to climate change problems and solutions. In a brainstorming session they wrote down things like the carbon cycle, emissions, just transition to renewable energy, ecosystem resilience, sea level rise, weather extremes, new ways of producing energy, and greening the Earth, and many other ideas.

They then tried to imagine how these ideas were linked to chemistry, biology, physics, and earth sciences. Good candidate ideas involved fundamental science ideas. That helped narrow the possibilities down. Then they wondered, could we identify a local example of a puzzle or problem to solve, or a climate-regeneration project to explore? How could this become relevant to our students and perhaps involve members of our community?

The teachers ended up with eight topics that each had robust science underlying them and that could be viewed a highly relevant by their students:

- Urban heat islands
- Wildfire ecology (how certain ecosystems depended on fires for rejuvenation and regrowth)
- Food waste and plant-based diets
- Coastlines as both carbon sinks and buffers against hazardous wastes
- Success stories of renewable energy developments in their state
- Fast fashion with its notorious contributions to greenhouse gas emissions and connections to oppressive labor practices in garment industries of the Global South
- The modeling of future temperatures and sea levels which would include the study of paleoclimatology
- A mini-unit on systems thinking with explorations of feedback loops and tipping points.

These weren't perceived as the *right* choices—there is no such thing. But this *was* a richly diverse mix of key ideas with potential to build on one another, if sequenced strategically.

Taken as a whole, these topics required deep thinking in various science disciplines; many could connect students with their community, some could require considering explorations of Indigenous worldviews to fully understand a sustainability problem or solution, and the teachers identified several places where both eco-anxiety and students' sense of agency could be addressed in non-trivial ways. Each unit fit into the scope and sequence of the larger curriculum with explicit connections. Each unit clearly built upon core ideas, scientific practices, and themes of justice that had been established in earlier units.

To wrap their heads around how these topics might be studied, they created a grid (shown in Figure 1). This helped them decide what order might make sense for coherent and cumulative learning. They also didn't want holes in their curriculum where ideas they valued might

Goals: ✓=Core to unit ~ = Some possibility X = Not featured in unit

Topics & their underlying science ideas		1. Local, real word phenomena	2. Involvement of community	3. Explore expansive worldviews	4. Students use sci. practices as epistemic tools	5. A 360^{0} consideration of R&R strategies	6. Attending to students' emotions	7. Opportunities for agency & activism
Urban heat islands	-Electromagnetic spectrum -Amplification of GHE -Albedo -Human metabolism	✓	✓	X	✓	✓	~	✓
Modeling temps. and sea levels	-Paleoclimatology -Role of oceans in climate and climate change -Modeling possible futures	X	X	X	✓	~	✓	X
Wind turbines in our community	-Renewables worldwide -Innovations in chem and physics of energy storage -Grid technologies	✓	✓	✓	~	✓	✓	~
Wildfire ecology	-Ecosystem functions, resilience -Carbon cycling -Indigenous stewardship of forests	~	~	✓	~	✓	~	X
Food waste & plant-based diets	-Land use as GHG source -Ecosystem destruction -Squandering resources -Nutritional alternatives	✓	✓	~	~	✓	~	✓
Coastlines as buffers and CO_2 sinks	-Stocks and fluxes in carbon sinks -Sea level rise effects -Natural buffers	~	~	~	✓	✓	~	~
Feedback loops and tipping points	-Bio. & physical systems -Positive feedback -Cascading effects creating instability in natural systems	X	X	~	✓	✓	✓	~
Fast fashion	-Chemistry of dyeing -Production of syn. fibers -Microplastics -Circular economies	✓	X	✓	~	✓	✓	✓

fall through the cracks. For each of the prospective units, they indicated the degree to which all seven of the considerations above could be addressed in that unit. For each unit they could check off whether each consideration could either be 1) core to the unit, 2) have some possibilities to integrate that idea in the unit, or 3) that the unit would not feature this idea. As you can see in Figure 1, there were opportunities to address each of the seven considerations multiple times when looking across the *entire year*, and inevitably, none of the units taken individually could address all the considerations. Trade-offs are not always a bad thing, it's part of the reality of getting into the details of teaching.

Just to give you a hint about the next planning steps: These teachers thought that the Greenhouse effect would be an appropriate place to start, given that nearly everything we associate with climate change begins with the human-amplified version of the GHE. They wanted to study this phenomenon in the context of urban heat islands, which were a real thing in their cities and linked to a history of racist housing policies from the early twentieth century. They decided to mix the science ideas that students would study (infra-red radiation, specific heat, albedo, evapotranspiration by plants) and alternate regenerative topics with those that were more sobering. They found that for some parts of the unit, learning opportunities for students could be expanded by adding in chances for them to collect data within their community or to do some background research on related mitigation strategies that the teachers had not thought of initially. After discussing all the topics at a planning meeting, teachers found that social justice was indeed relevant to their goals, and reconfigured their unit sketches to feature that. A year-long course gave them time to engage in activism with students, and to explore the social, cultural, historical and economic dimensions of climate change solutions.

Planning across grade levels

If you are coordinating how climate change might be taught across grade levels, then the planning could include elementary, middle and high school educators sitting down together to map out a full district level trajectory. It would be important to determine what might be taught in earlier grades, so that colleagues at higher grade levels could build upon key ideas, scientific practices, and study of local phenomena. You can use a version of the planning grid as shown in Figure 1, but it could span grades 2-5, 6-8, or 9-12.

You'd want to avoid too many repetitive conversations about eco-anxiety or doom-ish concerns about the future. Yes, we want students to develop emotional resilience, but constant sharing of one's tensions or sadness, especially in the same way over and over, is counterproductive. On the positive side, when you arrange the curriculum to span multiple grade levels, you can be purposeful about supporting different forms of activism and reinforcing students' sense of hope over time.

Take-aways

There are no perfect ways to organize curriculum around climate change. Give it time, meet with peers and have some initial conversations. Yes, you'll feel overwhelmed and under-prepared at first, but if you all do some targeted reading, that will help. Your first year could be a pilot; start small and take some data on how students respond and what you learn. Try going to climate change conferences that are state level or regional, the work of other educators may inspire you, or you may inspire them! Whatever you do—get started.

Final words on equity and justice in curriculum work

We conclude a statement from the curriculum development team of OpenSciEd about equity:

> *Instructional materials are rooted in a commitment to restorative justice through privileging multiple ways of knowing, being, and valuing as a fundamental human condition, and they promote the rightful presence for all students across the multifaceted scales of justice, including scales related to race, socioeconomic class, gender, educational sovereignty, Indigenous rights, immigration history, land and water rights, sexual orientation, gender expression, abilities, and other dimensions of social difference related to justice. From a critical historical perspective, working towards equity and justice involves implementing approaches that de-settle inequitable systems, routines, and assumptions that are likely to be in place in many educational institutions. In coordination, it is then possible to support expansive cultural learning pathways for youth working from an asset perspective. In particular, these pathways should be designed to center the life-worlds on non-dominant communities in support of multiple ways of knowing, being, and valuing.*