Crafting and Critiquing Climate Change Evidence Arguments

BY BRIAN E. GORDON

The most important issue facing our civilization is the existential threat of global climate change, making it imperative for our students to be climate literate in order to take action and create positive environmental and social change.

The September 2019 global climate strikes were proof of how invested young people are in the future of humankind and that of our planet. Therefore, shortly before going remote in the spring of 2020, each of my classes was tasked with publishing a climate change podcast series. One critical component to this unit of study on climate change was for students to analyze climate change data in order to argue from the evidence in their podcast episode.

I began by curating resources on padlets and sharing the links to each through Google Classroom. Padlets are online bulletin boards a teacher can use with any internet-enabled device to display information on a topic or have students use to share ideas with digital “sticky” notes. Over the course of four weeks, students worked remotely to access padlets on the internet. Students used the resources on the padlets to conduct research on four pieces of evidence that prove global climate change is accelerating and is a result of human activities: global warming, extreme weather events, melting ice, and sea level rise.

During this time, I saw my sixth-grade students for science two days a week, slightly more than one hour each day. One day was a teaching and working day that included a mini-lesson or discussion about the climate change data to be researched, time for questions and answers, research time for students to analyze the data and begin crafting an
initial argument, conferences and small groups to provide student support, and a short debrief at the end of class to discuss initial student data analysis and initial argument ideas. The other day was designated for an argument session.

One way to collect multiple student ideas and foster student collaboration is to use a shared online space. For this purpose, I used what I referred to with students as padlet argument boards. Students had the opportunity to share their arguments on their class padlet for each piece of climate change evidence and then critique each other’s arguments. Use of the padlet argument board provided a space for students to take part in the important scientific process of learning together by building scientific knowledge as a community (Schwarz, Passmore, and Reiser 2017).

Analyzing climate change data to craft scientific arguments was one part of a unit of study on climate change. Students critiqued arguments and other parts of the unit to prepare for drafting and publishing a podcast episode with their research partner. The steps involved in crafting and critiquing arguments from climate change evidence are explained throughout the rest of the article.

Climate change unit launch and forming student groups
The unit was launched (prior to teaching online) with the documentary Chasing Ice (see link in Online Resources) to introduce students to the broad concepts and subtopics of climate change. While we watched the video as a group, students captured key ideas and new concepts using the two-column note-taking strategy from Facing History and Ourselves (see link to Two-Column Note-Taking Strategy in Online Resources; see also box with Chasing Ice Documentary Two-Column Note Strategy). I paused throughout the documentary for students to do think-pair-shares to capture their own thoughts and those of their peers. Students shared their ideas as a whole class, and I documented student thinking on chart paper. I made sure to take pictures of the chart paper and post to Google Classroom, so students could refer to the ideas we captured in the classroom at home. For homework, students responded to each key idea in their notes with either a question they had or an interpretation or connection they made. Some examples of key ideas students came up with throughout the documentary are that

- Analyzing climate change data to craft scientific arguments was one part of a unit of study on climate change.
- Students critiqued arguments and other parts of the unit to prepare for drafting and publishing a podcast episode with their research partner.
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CONTENT AREA
Earth Science

GRADE LEVEL
6–8

BIG IDEA/UNIT
Arguing from climate change evidence in a podcast episode

ESSENTIAL PRE-EXISTING KNOWLEDGE
Conceptual understanding of the greenhouse effect

TIME REQUIRED
Depends on whether school is remote or in-person and how often you see students

COST
Three free padlets with Basic membership, unlimited padlets for $10/month with Pro membership or $96/year

SAFETY
Follow all school procedures to address internet safety/privacy.
carbon dioxide levels have been increasing steadily in the atmosphere as a result of human activity, that global warming is causing glaciers to melt quickly, and that extreme weather events are to become more frequent and intense. We started the next day of class by sharing students’ responses to key ideas before continuing with the documentary.

Following the unit launch, students previewed trade books and digital resources on padlets to decide which climate change subtopic they would focus on for their podcast episode (see Online Resources). Students were then organized into research partnerships and study groups based on their research interests. The subtopics students focused on in their research and podcast episodes were: the greenhouse effect, global warming, extreme weather events, melting ice, sea level rise, solar energy, wind energy, and hydroelectric energy.

Not only did this grouping approach allow for student voice and choice to increase engagement and make for an authentic project, but it also kept students from feeling that they were being stigmatized based on the kind of learner they were. As a result, all learners felt respected and collaboration in the differentiated classroom was maintained as a core value (Tomlinson 1995).

Analyzing a mentor scientific argument

When we gathered as a whole class to begin thinking about crafting scientific arguments, the initial focus was on analyzing a mentor scientific argument. The use of a mentor text served as a model argument for students to use when writing their own arguments so they could see how the author structured the writing and then emulate the author’s writing in their own work (Reed and Thompson 2019). We analyzed a mentor argument written by a seventh-grade science student because the quality of the argument writing was attainable for an end-of-year sixth-grade science student, and the writing clearly showed the different parts of a scientific argument with claim, evidence, and reasoning. The decision to use a mentor student argument focusing on a topic other than climate change was to ensure that the cognitive demand of writing scientific arguments about climate change was maintained for students.

To fully understand the work of crafting an argument, students would first need to identify where the claim, evidence, and reasoning were located in a mentor student argument. To do this, students worked with their research partner in a Zoom breakout room to color-code each part of the same student argument in their digital notebook that was shared with them on Google Classroom. For each lesson on the four pieces of climate change evidence, I created Google Slide digital notebooks with a Pear Deck add-on. The Pear Deck add-on is free and can be used with Google or Microsoft (see Online Resources). The purpose of including Pear Deck in the Google Slide notebook is to make the notebook more engaging and interactive for students, as well as to integrate formative assessments easily and support students with executive functioning needs asynchronously, offering them both flexibility and predictability.

<table>
<thead>
<tr>
<th>Chasing Ice Documentary</th>
<th>Two-Column Note-Taking Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Ideas:</strong> Main points of the documentary</td>
<td><strong>Response:</strong> Questions, Interpretations, and Connections</td>
</tr>
<tr>
<td>1) What are the most important ideas to remember?</td>
<td>1) What questions does this information raise for you? (Q)</td>
</tr>
<tr>
<td>2) What new terms or concepts have been introduced?</td>
<td>2) Why do you think this information is important and/or relevant to the unit of study on climate change? (I)</td>
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<tr>
<td></td>
<td>3) What other ideas, events, or texts does this information remind you of? (C)</td>
</tr>
<tr>
<td></td>
<td>4) How does this information connect to your own life? (C)</td>
</tr>
</tbody>
</table>
Using a graphic organizer, students recorded where each part of the mentor student argument was located and described what made each part of the argument strong and effective. Based on their analysis of the mentor argument, students used a rubric checklist template to organize their ideas for what the criteria should be when writing a claim, evidence, and reasoning in preparation for students development.

### Co-Constructing a Scientific Argument Checklist and Scientific Argument Writing Next Steps

<table>
<thead>
<tr>
<th>Scientific Argument Criteria</th>
<th>Yes!</th>
<th>Starting To</th>
<th>Not Yet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Claim</strong></td>
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<tr>
<td>I made a claim that answered the research question.</td>
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<tr>
<td>I made a claim that is scientifically correct.</td>
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<td></td>
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<tr>
<td><strong>Evidence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I provided appropriate evidence for supporting my claim.</td>
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<td></td>
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<tr>
<td>I provided multiple pieces of evidence to support my claim.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>I provided evidence that was scientifically accurate.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reasoning</strong></td>
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<tr>
<td>I provided reasoning that makes a link between the evidence and the claim</td>
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<tr>
<td>I included scientific principles or knowledge of scientific ideas to describe why the evidence supports the claim</td>
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</table>

### Scientific Argument Writing Next Steps

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<tbody>
<tr>
<td><strong>Self-Assessment</strong></td>
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<tr>
<td><strong>Peer Critique</strong></td>
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<tr>
<td><strong>Teacher Feedback</strong></td>
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</tbody>
</table>
ing their own scientific argument rubric checklist (see Turning a Mentor Scientific Argument into a Rubric Checklist in Supplemental Materials). We then came back together as a whole group to debrief the experience of analyzing the mentor student argument.

**Co-constructing a scientific argument rubric checklist**

Each student pair contributed ideas toward creating a class rubric for evaluating climate change arguments. The process of co-constructing a rubric checklist with students was beneficial because it made them aware of the assessment criteria, and it made it more likely that students would use the rubric checklist as a tool for self-assessment and peer critique because they had participated in its design (Bharuthram and Patel 2017).

To do this work, we started with examining the claim in the mentor student argument and discussing the criteria for what goes into making a claim. Each research partnership had the opportunity to share one criteria they had recorded on their rubric checklist. While students were sharing, I captured their thinking on sticky notes and placed those on chart paper. After each group had the chance to share, we voted on which were the best criteria that made for a strong and effective claim and those sticky notes were left on the chart paper. The process was repeated for evidence and reasoning until we had co-constructed a scientific argument writing rubric checklist (see Figure 1; see Co-Constructing a Scientific Argument Rubric Checklist and Scientific Argument Writing Steps in box; it is also available in Supplemental Materials).

**Climate change evidence research and crafting an initial scientific argument**

**Gathering evidence**

Students began to conduct research on global warming using their first of four major pieces of climate change evidence. Using a padlet containing links to resources about global warming that I curated and shared through Google Classroom, students engaged...
with at least two of each type of the following texts: graphs, videos, articles, and interactive simulations. While researching, students gathered global warming data that they thought could potentially serve as qualitative or quantitative evidence to support their claim in response to the research question: How has global temperature changed over the past century?

**Analyzing evidence**

To prepare students to work independently on analyzing and interpreting data, we analyzed a NASA Rising Global Temperature graph together as a whole group using the notice, wonder, story strategy (see Figure 2). This is an approach to analyzing data with many benefits. First, students were asked to record what they noticed about the graph in their notes, which is something that every student was able to do independently. This was followed by students recording any questions they wondered about the graph. Last, students recorded what they thought was going on in the graph and what story it told. Students did this activity as a think-pair-share, so they had the opportunity to jot their initial observations, questions, and analysis of the data in their digital notebook before pairing with their research partner to hear their thoughts. When I instructed students to share their thoughts with partners, I also encouraged them to record any new ideas that resulted from the conversation.

When we discussed as a whole group what students noticed, wondered, and thought the story of the graph was, students were able to make connections and build deeper comprehension of the data as they shared ideas with peers and built off of their initial thinking by looking at data in different and deeper, more meaningful ways (Mei 2018). For example, one student helped others see the cause-and-effect relationship between the enhanced greenhouse effect resulting from increased burning of fossil fuels and how that has led to the rising global temperatures observed in the graph.

**Ranking evidence**

After gathering and analyzing global warming evidence, I modeled for students how to rank evidence as high or low quality using evidence from a previous unit of study on ecology. I showed students how to use a checklist for ranking the evidence that provided them with specific criteria to use in evaluating evidence quality: accuracy, support for the claim, source reliability, difficulty to argue against, and persuasiveness (see Ranking Evidence Checklist in box). Student research pairs then discussed and ranked their evidence as high or low quality with the support of the checklist. After ranking evidence, stu-
dents picked their two best pieces of evidence to support their claim in response to the research question. We debriefed the experience of ranking evidence as a group at the end of class, and students volunteered to share pieces of evidence they were choosing to use in their arguments.

**Building reasoning**

Having made a claim and provided evidence to support that claim, students needed to provide reasoning to connect their evidence to their claim by incorporating relevant scientific ideas to justify their evidence. To support students with this work, they used the reasoning tool from The Argumentation Toolkit (see reasoning tool in Supplemental Materials). I explained to students that the reasoning tool can help them organize their ideas clearly as they craft a convincing initial argument with claim, evidence, and reasoning, and I showed them how they needed to connect their evidence with their claim by explaining the reason(s) why the evidence matters.

The purpose for modeling with content that was already familiar to students was so that they could just focus on the practice of incorporating reasoning into their argument writing, without needing to understand new science concepts at the same time (see Figure 3). I walked them through each part of the reasoning tool, first reading the research question and jotting down the strongest evidence I had gathered in the left column of the tool. This allowed me to be able to make an accurate claim in response to the research question in the right column of the tool. Then, to engage students with the reasoning process by activating their prior science knowledge, I had them do a think-pair-share to connect the evidence with the claim by discussing the scientific ideas that explain why the evidence matters.

After I modeled how to use the reasoning tool, research partnerships conducted more global warming research, now focusing on finding the scientific ideas that explain why their evidence supported their claim. Students practiced completing the reasoning tool independently before sharing their ideas with their peers and debriefing initial reasons at the end of class as a whole group.

**Self-assessing the initial scientific argument**

Once students had crafted their initial global warming argument with claim, evidence, and reasoning, they used the scientific argument rubric checklist to self-assess their writing (see Co-Constructing a Scientific Argument Writing Rubric Checklist in Supplemental Materials). Their job was to mark up the checklist in their digital notebook for each criteria listed under claim, evidence, and reasoning. For every criteria that they marked as “starting to” or “not yet,” they jotted next steps for themselves in the self-assessment box on the bottom of the checklist.

**Padlet argument board gallery walk**

**Initial peer praise and critique of scientific arguments**

Following self-assessment, students posted their initial global warming arguments to the padlet argument board. I explained to students that their task was to praise and critique the scientific arguments of at least two peers and respond to at least one peer who provided critique on their scientific argument.

Directions: Use the reasoning tool to explain how the pieces of evidence support the given claim in response to the research question.

Research Question: Is the Hudson a river, an estuary, or both?

<table>
<thead>
<tr>
<th>Evidence</th>
<th>This evidence matters because...</th>
<th>Therefore...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Reasoning)</td>
<td>(Claim)</td>
</tr>
<tr>
<td></td>
<td>The gravitational pull of the Sun and Moon on the Earth causes a rising and falling of tides in the Hudson twice daily. This proves that the Hudson is an estuary because it is connected to the Atlantic Ocean and is influenced by its tidal forces and saltwater.</td>
<td>The Hudson is both a river and an estuary.</td>
</tr>
<tr>
<td></td>
<td>According to the salinity data visualization for the lower half of the Hudson, salinity levels decrease the further you get from the mouth of the Hudson at New York Harbor and the closer you get to the Federal Dam in Troy, N.Y. Here, there is no trace of oceanic salt.</td>
<td>Rivers consist of naturally flowing freshwater. Even though the most northern lower part of the Hudson by the dam in Troy is influenced by tides, it is not influenced by salt, and is therefore considered a tidal river, not a tidal estuary.</td>
</tr>
</tbody>
</table>

Note: Adapted from The Argumentation Toolkit [https://bit.ly/3AZfKKj]
needs at the same time. Second, I shared a Google Doc with each student where I recorded the strengths of their scientific arguments and what needed improvement. Students told me having the document was helpful so they could refer to my feedback as needed; I also found it useful to reference what I wrote and track student progress. I repeated this same process with the remaining climate change topics.

**Reflections, tips, and future considerations**

This project was successful even though there were many challenges presented by teaching and learning remotely. The biggest success was that each class was ultimately able to produce a climate change podcast series, which meant that students found ways to collaborate remotely in research partnerships. Another huge success was that students used self-assessment, peer review, and teacher feedback to strengthen their talk in the podcast episodes. While receiving feedback can be difficult for students to embrace, it was evident that many were receptive to constructive criticism and recognized its importance in improving the quality of their work. In conversations with students during conferences and small groups, many mentioned that they felt positive social pressure not to let their peers down, the need to do their part for the collaborative class project, and that the work was relevant and important.

When thinking about next steps for this type of remote learning project, it’s worth considering best practices for how to ensure equal participation from all students, both in terms of their attendance during synchronous classes and their contributions to group work. While many students had success with crafting their scientific arguments, some students struggled, even with the various supports put in place. This project highlights the need to continue to develop strategies for increasing student engagement in remote learning environments.

Even though students had opportunities to be critical peers throughout the year in school, some students struggled with the idea of critiquing their friends and having other people see their feedback on the padlet argument boards. Creating a culture where this kind of knowledge building through critique is the norm could go a long way in getting students to understand the importance of this process for scientists, albeit remotely.

**FIGURE 4:** Example of a padlet argument board showing what a portion of a sea level rise argument board looked like for one of the classes. Students posted their initial arguments, critiqued the arguments of their peers, and responded to their peers who provided them with a critique.
Having students engage in argument from evidence is a critically important aspect of scientific practice in confirming and pushing knowledge further. When planning every unit of study throughout the year, it’s imperative to allow for multiple opportunities for students to engage in this work. Becoming proficient in communicating as scientists through crafting and critiquing arguments of peers makes for authentic scientific work and creates a classroom culture for students that shows them their voices and ideas are expected and valued as part of a community of learners.

**REFERENCES**


**ONLINE RESOURCES**

*Arguing From Evidence in Middle School Science*—https://bit.ly/3i58SCv


*Chasing Ice documentary*—https://chasingice.com


*Human Impacts on Our Climate, Grade 6: STEM Road Map for Middle School*—https://bit.ly/3AXaUxa


*Pear Deck*—https://www.peardeck.com/googleslides

*Pear Deck*—https://www.peardeck.com/help-videos

*Teach Climate Justice Campaign [Zinn Education Project]*—https://bit.ly/3biJliu


*Understanding Climate Change, Grades 7–12*—https://bit.ly/3kkeiwp

**SUPPLEMENTAL MATERIALS**

*Turning a Mentor Scientific Argument into a Rubric Reasoning Tool*—https://www.nsta.org/online-connections-science-scope

*Co-Constructing a Scientific Argument Writing Rubric Checklist*—https://www.nsta.org/online-connections-science-scope

*Connecting to the Next Generation Science Standards*—https://www.nsta.org/online-connections-science-scope

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**FIGURE 5:** Student critique of an argument on the padlet argument board.

<table>
<thead>
<tr>
<th>Minh Anh</th>
<th>Cole</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasoning: Ice melts when heat energy causes the molecules to move faster, breaking the hydrogen bonds between molecules to form liquid. In the melting process, the water molecules actually absorb energy.</td>
<td>I agree with your scientific argument, but next time maybe include something about thermal expansion which is basically heat causing water to expand, that’s another vital reason for sea levels to rise.</td>
</tr>
</tbody>
</table>

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