SUBJECT to® CLIMATE

Climate Education in the Classroom:

Student Impact Case Study

how can I . . .

how can I **help the planet**

how can I **make a difference**

how can I **feel positive**

how can I **use my voice**

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Citation

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Introduction

This study evaluated how SubjectToClimate lessons impact student knowledge, emotional responses, and agency related to climate change, while also examining how teachers experience and implement these lessons in the classroom. Our lesson plans are teacher-designed, interdisciplinary resources that are vetted by climate scientists and experienced educators, integrating justice, social and emotional learning (SEL), student action, and environmental literacy. Aligned with frameworks such as NGSS, C3, and IB, they are built to be classroom-ready, minimize teacher burden, and support meaningful, inclusive climate instruction across all subjects and grade levels.

Objective

This case study explores the impact of interdisciplinary climate lessons on both students and educators. Drawing on two sources:

1. Pre- and post- surveys from five classrooms across elementary, middle, and high school levels; and
2. Supplemental surveys from a broader cohort of teachers who have taken SubjectToClimate professional development or taught with SubjectToClimate resources.

Methodology

In Spring 2024, SubjectToClimate recruited elementary, middle, and high school educators. Participating teachers taught in various subject areas, including science, social studies, Spanish, and Special Education. After completing consent procedures (see Appendix C, Appendix D, and Appendix E), five teachers implemented a single SubjectToClimate lesson tailored to their grade level:

- **Elementary**: Introduction to Air Quality (with book: Why Is Coco Orange?)
- **Middle school**: Extreme Weather Lesson: Are Winters Getting Worse?
- **High school**: En-ROADS Climate Change Solutions (simulation tool by Climate Interactive)

Teachers administered student surveys before and after teaching the unit (see Appendix F), which measured climate knowledge, agency, and emotions.

This report also draws insights from surveys distributed to teacher cohorts before and after participating in SubjectToClimate professional development programs (see Appendix H), as well as surveys embedded across our platforms to assess the implementation of our educational materials (see Appendix I).

Acknowledgements

We extend our sincere gratitude to the educators who each taught a lesson: Pamela Fellner, Tina Ezzo, Breck Foster, and Jennifer Sirmans; and their students. We also thank the educators who took the time to fill out a survey on our platforms and offer their valuable feedback.

Key Takeaways

After teaching about climate change with SubjectToClimate materials, teachers observed the following outcomes around student knowledge and agency, while also sharing their experiences using these materials.

Student Knowledge

Across all grade levels, students increased their understanding of the climate concepts addressed in the lesson they completed during class. Knowledge was measured by assessing correct answers on quizzes that asked about climate concepts addressed in the lesson (each lesson had distinct knowledge questions).

83%
was the average post-test score on a lesson's climate concepts.

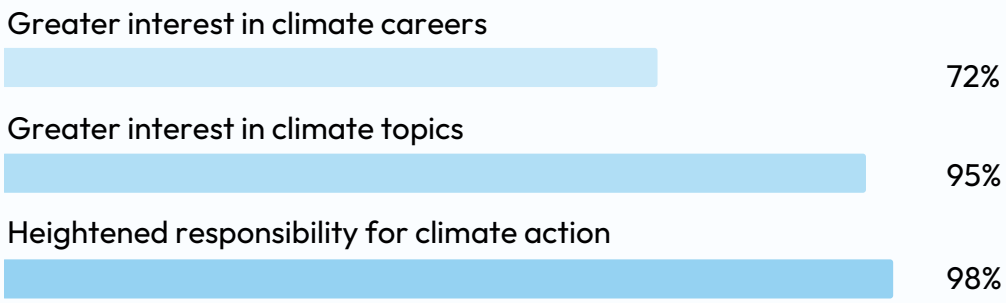
+15%
was the largest knowledge gain, among middle school students.

94%
of surveyed teachers reported increased climate knowledge.

Student Agency

Students identified collaborative, tangible actions to address climate change and demonstrated motivation and readiness to engage with peers, family, and the community.

After their students engaged with SubjectToClimate materials, teachers observed:



After investigating climate impacts and discussing the topics with their classmates, students became more worried about climate change. However, they also reported feeling **more** hopeful and determined, and **less** doubtful and powerless.

Teacher Experience

Educators found SubjectToClimate lessons easy to integrate into existing curricula with minimal prep time (in fact, some noted that SubjectToClimate's lesson plan format enabled them to integrate climate topics into their curriculum in just a couple of days). They appreciated that the materials were truly interdisciplinary, allowing for more flexibility in bringing up climate change while meeting required learning standards.

Results

Student Knowledge

Survey questions to test student knowledge (see Appendix F) were based on specific content covered in the lesson plan. Students across all grade levels showed increased belief in the scientific consensus on climate change.

Elementary students demonstrated competence in describing air quality concepts and asked stimulating questions about air pollution. Figure 1 shows samples of elementary student mind maps; these were were used at the beginning of the lesson to generate questions and ideas about air pollution, and students returned to them later in the lesson to answer their initial questions.

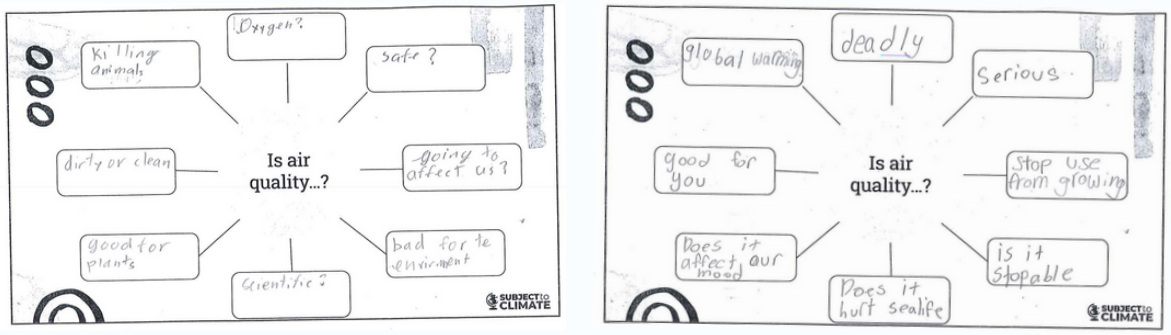


Figure 1

Middle school students improved their understanding of atmospheric climate impacts and their corresponding effects on weather patterns. This grade band demonstrated the highest knowledge gain (+15%), reaching an average score of 93% accuracy on their post-lesson quiz. High school students averaged 79%, and elementary students 76% (see Figure 2).

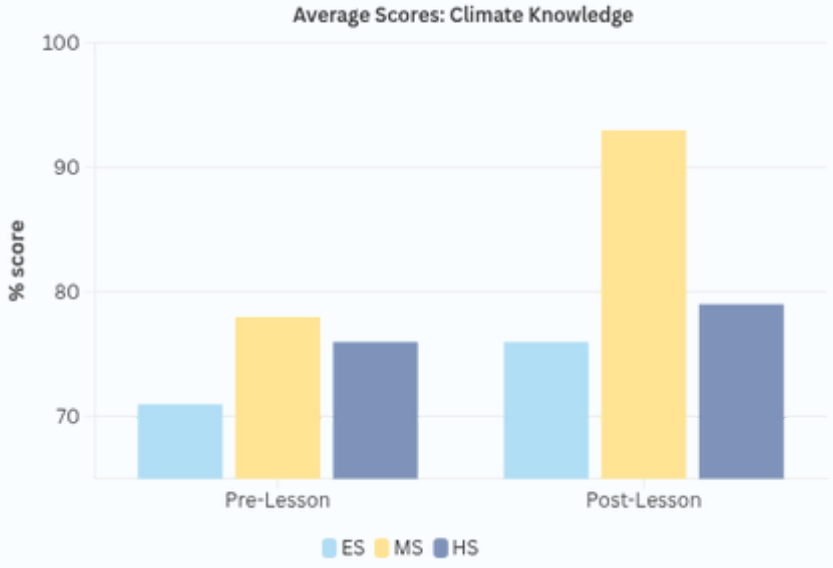


Figure 2

Results

Student Knowledge (cont.)

High school students modeled effective climate solutions, using the En-ROADS simulator to analyze projected emissions scenarios, while building their knowledge about the ripple effects of climate-related decisions such as increasing the price of carbon or subsidizing renewable energy through tax credits.

After teaching the En-ROADS lesson on climate solutions, a high school Special Education teacher shared the following about her students:

> "...[the lesson] helped with their critical thinking skills and analysis skills... [T]eaching about climate change made students more interested and engaged, particularly because it relates to their daily lives, contrasting it with other topics like ecology that may not elicit the same level of interest."

Teachers also emphasized how core instructional goals were met: 100% of surveyed educators reported that their students met key academic objectives and learning standards for their subject and grade with SubjectToClimate materials.

Student Agency

SubjectToClimate resources are designed to go beyond knowledge acquisition and help students translate climate awareness into action. In doing so, these lessons support students' socioemotional well-being while fostering real-world engagement. Across grade levels, students demonstrated a growing ability to connect classroom learning with observable environmental issues and personal or collective responses. They also illustrated an understanding of the disproportionate impacts of climate change on vulnerable populations.

At the elementary school level, students felt more empowered to recognize how climate impacts vary across different groups of people. Several students also made the connection between what they learned about air quality and firsthand experiences, such as the smoke from recent Canadian wildfires and poor local air quality.

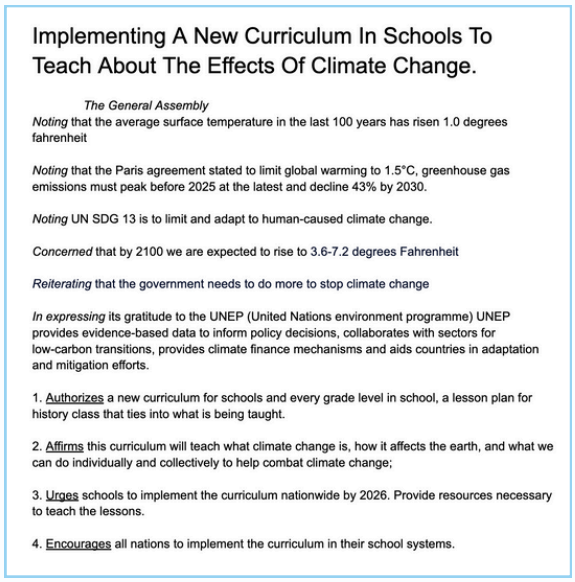
Middle school students recognized the importance of collaboration and identified age-appropriate ways to contribute to solutions, including communicating climate messages to friends and family, conserving electricity usage in the home, or shifting their purchases to more eco-conscious brands.

Among high school students, 75% reported that they engage in specific activities to reduce the negative effects of climate change (a 10% increase between pre- and post-surveys). These actions included reducing meat consumption, using public transportation, recycling, or making more intentional food and retail choices. While largely individual, these actions reflect growing awareness and personal responsibility felt by students around climate-conscious decision-making.

Results

Student Agency (cont.)

In addition to personal behavior changes, high school students showed interest in applying what they learned to broader systems thinking. During a Model UN simulation held after engaging with a SubjectToClimate lesson, several high school students chose to focus their proposals on climate-related challenges, demonstrating how recent learning shaped their perspective. One student proposed a plan to mitigate heat disparities during Oregon's heat dome, while another advocated for climate education as a long-term solution (see Figure 3). These examples illustrate how structured activities can prompt students to think beyond personal behavior and advocate for collective, systems-level change.



Implementing A New Curriculum In Schools To Teach About The Effects Of Climate Change.

The General Assembly

Noting that the average surface temperature in the last 100 years has risen 1.0 degrees fahrenheit

Noting that the Paris agreement stated to limit global warming to 1.5°C, greenhouse gas emissions must peak before 2025 at the latest and decline 43% by 2030.

Noting UN SDG 13 is to limit and adapt to human-caused climate change.

Concerned that by 2100 we are expected to rise to 3.6-7.2 degrees Fahrenheit

Reiterating that the government needs to do more to stop climate change

In expressing its gratitude to the UNEP (United Nations environment programme) UNEP provides evidence-based data to inform policy decisions, collaborates with sectors for low-carbon transitions, provides climate finance mechanisms and aids countries in adaptation and mitigation efforts.

1. Authorizes a new curriculum for schools and every grade level in school, a lesson plan for history class that ties into what is being taught.

2. Affirms this curriculum will teach what climate change is, how it affects the earth, and what we can do individually and collectively to help combat climate change;

3. Urges schools to implement the curriculum nationwide by 2026. Provide resources necessary to teach the lessons.

4. Encourages all nations to implement the curriculum in their school systems.

Figure 3

This trend of increased student agency following the use of SubjectToClimate materials was reinforced in surveys collected from general platform users as well as teachers who participated in SubjectToClimate professional development. Teachers who responded to these surveys reached over 4,000 students in total. They observed the following amongst their students:

Additionally, teachers described how student curiosity often extended beyond the classroom: several reported that students revisited a lesson's topic with follow-up questions weeks after teaching it, or asked to repeat activities they found meaningful. One high school teacher shared that their class launched a campaign to bring more local food to their cafeteria. An elementary educator highlighted how age-appropriate lessons helped students build early understanding of climate concepts, laying the groundwork for future engagement and action.

Results

Student Agency (cont.)

Emotional Shifts

Along with increased personal agency and motivation to engage in pro-environmental behaviors, students also demonstrated notable emotional shifts. Across grade levels (see Figure 4), self-reported feelings of hope and determination rose (from 24% to 31%), while feelings of powerlessness and doubt dropped (from 33% to 24%).

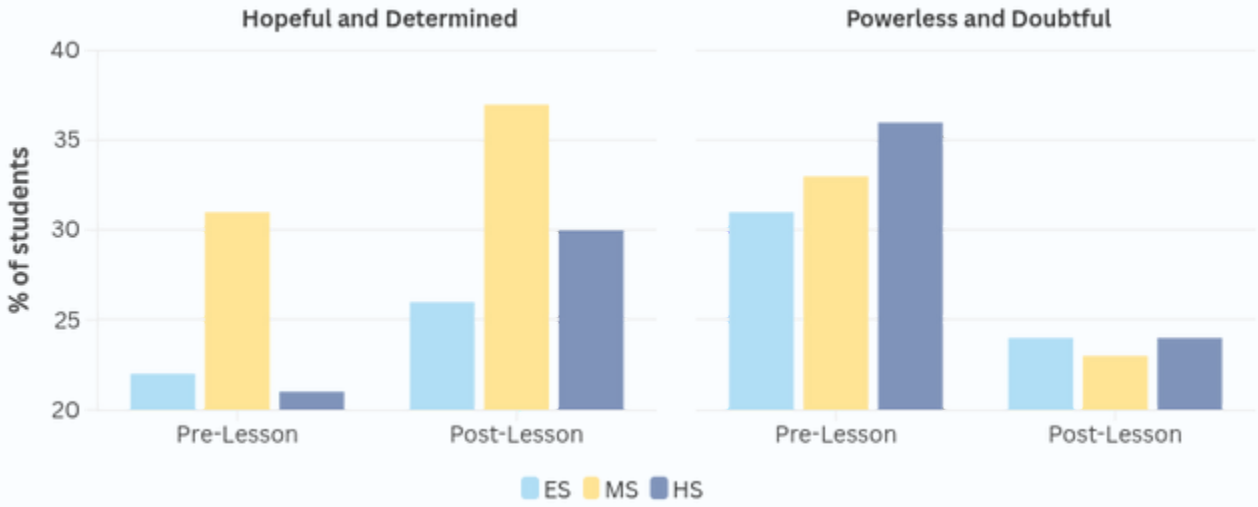


Figure 4

These emotional shifts aligned with teachers' observations that students often begin climate lessons feeling either overwhelmed or indifferent; this is unsurprising given the prevalence of climate anxiety and despairing rhetoric around climate change found on social media and the news. To combat these influences, many educators intentionally emphasize hopeful, action-oriented narratives and search for educational materials to this effect. This approach is especially critical at the elementary level, where foundational attitudes are formed.

One elementary student shared:

> "I learned that air quality is not always bad. It just tells us the quality of the air… I was thinking about the wild fires last year. They were [probably] rated purple."

Their teacher highlighted how the lesson's emphasis on agencies like the EPA led to valuable discussion (some students were familiar with the agency and others were not), prompting reflection on public awareness and the government's role in protecting communities.

Results

Teacher Feedback

Teachers praised the clarity, structure, and zero-prep nature of SubjectToClimate lessons:

- "Every step of the way is laid out for you, exactly what you need. So it's really low burden."
- "I've never had so many things tie in together in such a short amount of time—that's amazing."

Educators emphasized that SubjectToClimate lessons aligned with academic standards and could be integrated into core subjects, with an elementary educator remarking how they also tied into preparation for state testing. This enabled teachers to cover climate topics while meeting mandatory education requirements. Teachers also expressed how easily the materials can be left with a substitute, enabling seamless implementation of climate learning.

Future Work

These results show that even a single SubjectToClimate lesson can spark measurable growth in student understanding, engagement, and readiness to act on climate issues. To build on these results, future studies should:

1. **Expand beyond teacher-reported data to measure student perspectives.** We aim to collect direct feedback from students to better understand how our lessons impact their learning, emotional responses, and agency. This might include both formal studies and built-in lesson assessments on our platform, enabling more comprehensive outcome analysis while also providing teachers with benchmarks.

2. **Examine differences between climate-engaged teachers and those newer to the topic.** This would distinguish between classrooms that are already exposed to climate education and those that have never discussed climate topics.

3. **Evaluate multi-lesson units over longer timeframes.** This will provide deeper insight into how student knowledge and outlooks on climate change evolve over time with sustained educational interactions.

Our team is currently partnered with The College of New Jersey and Suffolk University on a project funded by the Spencer Foundation to conduct deeper evaluations of the impact of climate education on students, with a focus on recognizing and productively responding to climate emotions.

Results

Summary & Conclusion

Findings from this report suggest that SubjectToClimate lessons:

- Lower the barrier for integrating climate education into K-12 classrooms;
- Prompt authentic inquiry and student-led exploration into climate topics; and
- Foster student agency and empowerment.

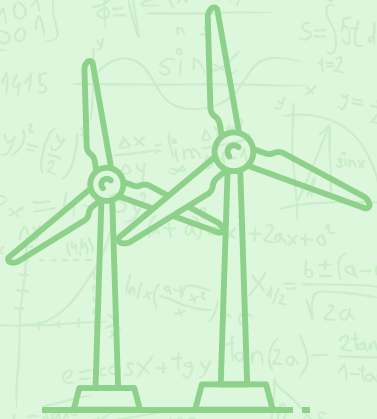
Since these outcomes were driven by embedding climate education across core subjects, SubjectToClimate will continue to expand pathways for educators to integrate climate change into existing standards, making it both as seamless and meaningful as possible.

High-quality climate education holds largely untapped potential to drive climate action at scale. With nearly 50 million students attending U.S. public schools, even modest behavioral shifts can generate substantial impact.

Untapped Potential

One study (Cordero et al., 2020) found that education alone could reduce a student's annual CO2 emissions **by nearly three tons**.

If scaled globally across secondary students in high- and middle-income countries, the resulting 18.8 gigaton reduction by 2050 would **exceed the projected impact of electric vehicles or offshore wind power**.



To unlock this potential, students must first gain the knowledge, skills, and confidence to engage with climate solutions. And that process starts with educators! If teachers are equipped to guide their students through this learning, without shouldering additional burdens, this possibility turns into a reality. SubjectToClimate fills a critical gap, delivering classroom-ready resources that empower both educators and students to respond meaningfully to the climate crisis.

Appendix A: Lesson Plan Breakdown

Lesson and Duration	Grade Level(s)	Subject(s)	Synopsis
Introduction to Air Quality Lesson 45 minutes	3–5	English Language Arts	This lesson introduces students to air quality.
Inquire: Using a KWL chart, students brainstorm what they know about air quality and what they want to learn. **Investigate**: Students read Why Is Coco Orange?, a story about a chameleon and how his skin changes color depending on the air quality. **Inspire**: Students complete a journal entry based on the lesson.			
Extreme Weather Lesson: Are Winters Getting Worse? 1 hour 30 minutes	6–8	Science, Earth and Space Sciences	In this lesson, students discover how climate change could be making extreme winter weather worse.
Inquire: Students discuss extreme weather events they have experienced and watch a video about extreme winter weather. **Investigate**: Students dive deeper into the polar vortex and lake effect snow, learning about how they may relate to climate change. **Inspire**: Students complete a jigsaw activity to explore two different examples of extreme winter weather events related to the polar vortex and lake effect snow.			
Science Lesson: En-ROADS Climate Change Solutions 1 hour 45 minutes	9–12	Science, Social Studies, Engineering	In this lesson, students explore the effectiveness, co-benefits, and equity of climate solutions and create a climate action scenario to limit global warming to 1.5°C using Climate Interactive's En-ROADS simulator.
Inquire: Students wonder about the composition of the atmosphere and analyze the relationship between global temperature and atmospheric CO2. **Investigate**: Students become familiar with the En-ROADS simulator and explore the real-world impact of different climate actions, including the co-benefits, equity considerations, and effect on global temperature. **Inspire**: Students create an En-ROADS scenario of effective and equitable climate actions that limits the rise in global temperature to 1.5°C by the year 2100.			

Appendix B: Data Collection and Analysis

Surveys

There were 64 pairs of pre- and post-test responses across all grade bands, with 26 high school pairs and 19 of each middle and elementary school grades. The data collected did not include personal identifiers.

Surveys were posted across our platforms (core site and state Hubs) for teachers to anonymously respond and offer their firsthand insights. Over 60 teachers reported their observations after using SubjectToClimate lessons, units, or activities approximately 4,000+ students.

Student Work

Student work samples were used purely as evidence or examples in the case study only when granted permission by their parent or guardian.

Teacher Interviews

The classroom educators were each interviewed separately after they finished teaching the lesson to gain insight on the results and discuss their presentation in this impact case study.

Appendix C: Teacher Consent Form

I agree to participate in the impact case study conducted by SubjectToClimate staff about climate change education in local classrooms.

I understand and consent to the use of interview recording(s) and notes for this study. I affirm that the notes taken by SubjectToClimate staff, during the session and based on recordings, accurately reflect my knowledge and perspective. I understand that SubjectToClimate will contact me before including any identifying information in their study.

I understand that participation in this study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study facilitator.

Please sign below to indicate that you have read and you understand the information on this form and that any questions you might have about the session have been answered.

Date: _____

Print Your Name:

_____

Sign Your Name:

_____

Appendix D: School Agreement Form

School Name	School Address
Name of Head of School	Class Grade Level
Email Address of Head of School	Number of Students in Class

Who We Are

SubjectToClimate is a nonprofit online connector for K–12 leaders of all subjects to find credible, unbiased, and engaging materials on climate change at no cost. We provide a hub of credible and engaging teaching materials on climate change for educators to easily find the resources they need. This consists of:

- Resources from other organizations that we curate and add synopsis, teaching tips, and scientists notes.
- Inquiry-based lesson plans are developed internally (also known as SubjectToClimate Lesson Plans).

Purpose

We would love to collaborate with [insert teacher name] and their classroom at your school. We are interested to see how SubjectToClimate material impacts the following:

- Climate change knowledge
- Attitudes about climate change
- Motivation to take action and behavior changes

What will the project involve?

- Teachers will identify the SubjectToClimate lesson plan and resources they are planning to use.
- We will administer a pre-and post-test survey to measure change in student attitudes and beliefs about climate change.
- Teachers will share student work with us from the lesson plan, if applicable.

Appendix D: School Agreement Form

How will we support you?

We will be available to support teachers during the planning process, and help them identify appropriate resources to use. As an optional add-on, we will be available to be interviewed by students to help with their research.

Timeline	Deliverables
Week 0	SubjectToClimate to send proposed pre- and post-test surveys and consent letters to the teacher, who will distribute them to parents and administrators.
Week 1: Day 1 pre-lesson	SubjectToClimate will send out the pre-test survey.
Week 1: Days 2–3 lesson plan implementation and post-lesson	Teacher will teach the lesson and communicate results with SubjectToClimate. The post-test survey will be distributed for students to take after the lesson.
Week 2 share student work	Teacher will send results to SubjectToClimate.
Week 4 draft of analysis	SubjectToClimate will share a draft of the analysis.

How will we protect your school's and students' privacy?

- The school name and location will only be used if the school consents to do so.
- Students and parents will be informed of the purpose of the collaboration. It will be made clear that the purpose is to evaluate the effectiveness of SubjectToClimate, and NOT student performance.
- Interviewing students or getting access to their work will be optional, and will not be done without student and parent consent. Sharing student work on our platform will only be done with written consent from both parents and students.
- All data collected from the surveys will be anonymized in our data collection process, data analysis and findings (we will never have access to who the answers are coming from).
- The published materials—including video, audio, images, quotes, anecdotes, and the report—will be shared with the school for approval prior to publication.

The school/teacher/student can pause, cancel, or stop participation at any time.

Appendix E: Parent Consent Forms

Dear parents,

I am excited to let you know that our class will be participating in a study on how climate change education can influence student's level of knowledge about climate change, their attitudes about climate change, and their behavior and/or abilities to take action.

We are working with SubjectToClimate, a nonprofit online connector that provides credible, unbiased, and engaging materials on climate change for K–12 students and teachers of all subjects at no cost via their online resource database (subjecttoclimate.org).

What will the project involve?

1. Your teacher will teach a lesson plan designed by SubjectToClimate.
2. We will administer a pre- and post-lesson test designed in collaboration with SubjectToClimate to measure change in student knowledge and attitudes about climate change.
3. After receiving parent consent, we will share student work with SubjectToClimate for impact analysis.

How will we protect your child's privacy?

All data collected from the pre- and post-test surveys will be anonymized in our data collection process, data analysis, and findings, so we will never have access to which students' work we are analyzing.

When sharing your child's work, their first name and age will only be displayed if we receive your consent to do so. Interviewing students or getting access to their work will be optional, and will not be done without student and parent consent. Sharing student work on our platform will only be done with written consent from both parents and students.

Please sign and return the form on the next page.

Appendix E: Parent Consent Forms

Please sign and return the form below:

I, _____ give my consent for _____
guardian's name child's name

to do the following:

(check all that apply)

- ☐ Participate in the pre- and post-test surveys.
- ☐ Share their work with SubjectToClimate (for internal analysis, not for published quotes or photos)
- ☐ Share their work with SubjectToClimate (for analysis and for published quotes or photos)
- ☐ Have their first name and age shared on SubjectToClimate publications*

* The school, teacher, and/or student can pause, cancel, or stop participation at any time.

_____ _____
parent or guardian's name parent or guardian's signature

Appendix F: Student Surveys with Answer Keys

Elementary School: Introduction to Air Quality (Air Quality #1)

Some questions are derived from the YPCCC document linked here. Correct: **BOLD** Incorrect: Underlined.

1. Do you believe that climate change is happening?
   - Yes
   - No
   - I don't know
2. Do you think climate change is caused by:
   - People
   - Natural changes
   - **Both people and natural changes**
   - Neither because climate change is not happening
   - I don't know
3. How worried are you about climate change?
   - Very
   - Somewhat
   - Not at all
4. How much do you think climate change will harm you?
   - I don't know
   - Not at all
   - Only a little
   - A great deal
5. Which emotions (if any) do you feel about climate change?
   - Sad
   - Worried
   - Nervous
   - Confused
   - Brave
   - Hopeful
   - No opinion
6. How much do you think climate change will harm plants and animals?
   - Not at all
   - Only a little
   - **Somewhere in the middle**
   - **A lot**
   - I don't know

Appendix F: Student Surveys with Answer Keys

Elementary School: Introduction to Air Quality (Air Quality #1)

7. How much do you think climate change will harm future generations?
   - Not at all
   - Only a little
   - **Somewhere in the middle**
   - **A lot**
   - I don't know
8. When do you think climate change will start harming people in the U.S.?
   - **They're already being harmed**
   - In 10 years
   - In 25 years
   - In 50–100 years
   - Never
9. Schools should teach students more about the causes, effects, and solutions to climate change.
   - Strongly agree
   - Agree
   - No opinion
   - Disagree
   - Strongly disagree
10. How often do you talk about climate change with your friends and family?
    - All the time
    - Sometimes
    - Never
11. How often do you hear about climate change from sources like TV or the internet?
    - At least once a day
    - At least once a week
    - At least once a month
    - A few times a year
    - Once a year or less often
    - Never
12. What is air pollution?
    - The amount of water vapor in the air
    - **Substances in the air that have harmful effects**
    - Weather like fog and mist
    - The weight of air molecules pressing down on Earth

Appendix F: Student Surveys with Answer Keys

Elementary School: Introduction to Air Quality (Air Quality #1)

13. What contributes to air pollution?
    - Walking to school
    - **Driving cars and trucks**
    - Riding bikes
    - All of the above
    - None of the above
14. What is the Air Quality Index?
    - A weather forecast
    - A measure of how much moisture is in the air
    - Air temperature
    - **A rating that tells us if the air is clean or dirty**
15. What leads to an orange Air Quality rating?
    - Hot weather
    - **Ozone in the air**
    - Rainy days
    - Big winds
16. Where does ozone mostly come from?
    - Water
    - Plants
    - **Pollutants**
    - Animals
17. What is the Environmental Protection Agency (EPA)?
    - Part of the U.S. government
    - A group that protects human health and the environment
    - A group that makes regulations to keep our air, land, and water clean
    - **All of the above**
    - None of the above

The next section contains short answer questions.

18. Do you see climate change happening around you? If so, how?
    - **Looking for improvement in their ability to talk about climate change**
19. What do you feel about climate change?
    - **Looking at how (if at all) their emotions changed regarding the reality of climate change**

Appendix F: Student Surveys with Answer Keys

Middle School: Are Winters Getting Worse?

Some questions are derived from the YPCCC document linked here. Correct: **BOLD** Incorrect: Underlined.

1. Do you believe that climate change is happening?
   - Yes
   - No
   - I don't know
2. Most scientists agree that climate change is occurring.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
3. Assuming climate change is happening, do you think it is:
   - **Caused mostly by human activities**
   - Caused mostly by natural changes in the environment
   - None of the above because global warming is not happening
   - Other
   - Don't know
4. How worried are you about climate change?
   - Very
   - Somewhat
   - Not at all
5. How much do you think climate change will harm you personally?
   - I don't know
   - Not at all
   - Only a little
   - A great deal
6. Select the emotions (if any) you personally feel about climate change:
   - Alarmed
   - Concerned
   - Powerless to make a difference
   - Cautious
   - Disconnected
   - Doubtful
   - Dismissive
   - Determined to make a difference
   - Hopeful
   - Optimistic
   - No opinion

Appendix F: Student Surveys with Answer Keys

Middle School: Are Winters Getting Worse?

7. How much do you think climate change will harm plants and animals?
   - Not at all
   - Only a little
   - **Somewhere in the middle**
   - **A great deal**
   - I don't know
8. How much do you think climate change will harm future generations?
   - Not at all
   - Only a little
   - **Somewhere in the middle**
   - **A great deal**
   - I don't know
9. When do you think climate change will start harming people in the U.S.?
   - **They're already being harmed**
   - In 10 years
   - In 25 years
   - In 50–100 years
   - Never
10. Schools should teach students more about the causes, effects, and solutions to climate change.
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree
11. How often do you discuss climate change with your friends and family?
    - All the time
    - Occasionally
    - Rarely
    - Never
12. How often do you hear about climate change in the media?
    - At least once a day
    - At least once a week
    - At least once a month
    - Several times a year
    - Once a year or less often
    - Never

Appendix F: Student Surveys with Answer Keys

Middle School: Are Winters Getting Worse?

13. What is lake-effect snow?
    - Snowfall near a lake
    - Snowfall caused by warm air blowing over freezing lake water
    - **Snowfall caused by cold air blowing over warm lake water**
    - Freezing rain near a lake
14. What is the polar vortex?
    - An area of high pressure near the polar regions
    - **An area of low pressure near the polar regions**
    - A warm winter
    - An area low pressure near the equator
15. What is the jet stream?
    - Rain that occurs near the equator
    - A band of high-altitude wind flowing from east to west
    - An ocean current
    - **A band of high-altitude wind flowing from west to east**
16. How does a disrupted jet stream impact global communities (if it does at all)?
    - Prolongs droughts and floods
    - Impacts where farmers can grow crops
    - Affects the frequency of heat waves
    - **All of the above**
    - None of the above

The next section contains true or false questions.

17. A faster-warming Arctic weakens and destabilizes the jet stream.
    - **True**
    - False
18. Climate and weather mean pretty much the same thing.
    - True
    - **False**
19. Climate change has already impacted weather patterns around the world.
    - **True**
    - False
20. Extreme winters are evidence that global warming may not be happening.
    - True
    - **False**
21. Warming temperatures in the Arctic can impact the weather at a global scale.
    - **True**
    - False

Appendix F: Student Surveys with Answer Keys

Middle School: Are Winters Getting Worse?

22. Vulnerable populations are often impacted more severely by extreme weather events, including rising temperatures.
    - **True**
    - False

The next section contains short answer questions.

23. What actions can you personally take to decrease the negative effects of climate change?
    - **Looking for improvement in their ability to articulate their personal role in the fight against climate change**
24. Do you already engage in some of these activities (if so, which)? If not, do you plan to?
    - **Looking at how (if at all) their emotions changed regarding actionable steps**
25. How are vulnerable populations disproportionately affected by climate change?
    - **Looking for improvement in their ability to articulate how vulnerable populations are affected**
26. How can you help vulnerable people in your community?
    - **Looking for improvement in their ability to articulate what they can do to help vulnerable people in their community**
26. How can you communicate the risks of extreme weather to your family, classmates, and local community?
    - **Looking for improvement in their knowledge of how to take local action and how to talk about it**

Appendix F: Student Surveys with Answer Keys

High School: Climate Solutions Scenarios with En-ROADS

Some questions are derived from the YPCCC document linked here. Correct: **BOLD** Incorrect: Underlined.

1. Do you believe that climate change is happening?
   - Yes
   - No
   - I don't know
2. Most scientists agree that climate change is occurring.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
3. Assuming climate change is happening, do you think it is:
   - **Caused mostly by human activities**
   - Caused mostly by natural changes in the environment
   - None of the above because global warming is not happening
   - Other
   - Don't know
4. How worried are you about climate change?
   - Very
   - Somewhat
   - Not at all
5. How much do you think climate change will harm you personally?
   - I don't know
   - Not at all
   - Only a little
   - A great deal
6. Select the emotions (if any) you personally feel about climate change:
   - Alarmed
   - Concerned
   - Powerless to make a difference
   - Cautious
   - Disconnected
   - Doubtful
   - Dismissive
   - Determined to make a difference
   - Optimistic
   - Hopeful
   - No opinion

Appendix F: Student Surveys with Answer Keys

High School: Climate Solutions Scenarios with En-ROADS

7. How much do you think climate change will harm plants and animals?
   - Not at all
   - Only a little
   - **Somewhere in the middle**
   - **A great deal**
   - I don't know
8. How much do you think climate change will harm future generations?
   - Not at all
   - Only a little
   - **Somewhere in the middle**
   - **A great deal**
   - I don't know
9. When do you think climate change will start harming people in the U.S.?
   - **They're already being harmed**
   - In 10 years
   - In 25 years
   - In 50–100 years
   - Never
10. Schools should teach students more about the causes, effects, and solutions to climate change.
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree
11. How often do you discuss climate change with your friends and family?
    - All the time
    - Occasionally
    - Rarely
    - Never
12. How often do you hear about climate change in the media?
    - At least once a day
    - At least once a week
    - At least once a month
    - Several times a year
    - Once a year or less often
    - Never

Appendix F: Student Surveys with Answer Keys

High School: Climate Solutions Scenarios with En-ROADS

13. Which energy source contributes the most to Particulate Matter (2.5 micrometer) air pollution?
    - Natural gas
    - **Coal**
    - Oil
    - Bioenergy
14. In order to address climate change, we need to:
    - Reduce carbon emissions
    - Remove carbon dioxide from the atmosphere
    - Transition to a green energy infrastructure
    - **All of the above**
    - Do nothing, it'll handle itself without human intervention
15. What is climate equity?
    - Recognizing the unequal burdens made worse by climate change
    - Ensuring all people take part in and benefit from climate protection efforts
    - Addressing the disparity in how climate change impacts different communities
    - **All of the above**
16. If the price of carbon increases, what will happen to global greenhouse gas net emissions?
    - **Decrease**
    - Stay the same
    - Increase
17. In what ways can diet choices and food production methods reduce net greenhouse gas emissions? Select all that apply.
    - Eating more animal products
    - Reducing use of fertilizers and pesticides
    - Reducing food waste
    - Using more land for crop production
    - Investing in efficient methods of food transportation
    - Improving manure management
    - Eating more plant-based foods

Appendix F: Student Surveys with Answer Keys

High School: Climate Solutions Scenarios with En-ROADS

18. When comparing the implications of deforestation (clearing of forested land) vs. afforestation (establishing forests in areas without tree cover), which statement is NOT true?
    - Deforestation and afforestation each have the same effect on global temperature rise.
    - Afforestation actions will take approximately 20 years to slow global warming.
    - Reducing methane and other gases emissions is more effective in reducing the rise in global temperature compared to both deforestation and afforestation.
    - **Afforestation can help support ecosystems without compromising justice for indigenous people who may claim a cultural interest in protecting land.**
19. If renewable energy is subsidized through tax credits, its demand will _____, and net greenhouse gas emissions will _____.
    - Decrease, decrease
    - Decrease, increase
    - Increase, increase
    - **Increase, decrease**
20. Without any actions to slow global warming, the probability of an ice-free arctic summer is projected to be _____ by the year 2100.
    - 25%
    - 50%
    - 75%
    - **100%**

The next section contains short answer questions.

21. What are three sources of carbon emissions in the U.S.?
    - **Looking for answers like coal mining, burning fossil fuels in power plants, drilling for oil, landfill waste, deforestation, transportation, heating and cooling buildings (from the En-ROADS simulator)**
22. What actions can you personally take to decrease the negative effects of climate change?
    - **Looking for improvement in their ability to articulate their personal role in the fight against climate change**
23. Do you already engage in some of these activities (if so, which)? If not, do you plan to?
    - **Looking at how (if at all) their emotions changed regarding actionable steps**
24. How can you communicate the risks of extreme weather to your family, classmates, and local community?
    - **Looking for improvement in their knowledge of how to take local action and how to talk about it**

Appendix G: Teacher Interview Questions

Impact on Student Knowledge

1. What did you observe in terms of student knowledge during the lesson and in student work afterwards?
2. Did the SubjectToClimate lesson engage your students in the material (as often climate change topics can engage students more in class material because they are relevant and important to students)?
3. Did you notice that the lesson helped convey critical STEM concepts to your students/increase knowledge on certain STEM topics in your curriculum?

Impact on Student Attitude

1. What did you observe about your students' attitudes towards climate change; did the lesson seem to make climate change more important to them?
2. After the lesson, students were more worried about climate change, but also more hopeful at the same time. Does this reflect what you saw in the classroom?

Impact on Student Behavior

1. Have you observed any behavior changes since teaching the lesson?
2. Have students brought up climate change in your class before? How does this compare to now?
3. For this lesson or in general, what would you notice is the biggest impact that you see among students?

Teaching Experience

1. What was your experience teaching this lesson?
2. Did the lesson format make sense? How was the implementation from paper to practice?
3. What feedback do you have on the lesson in terms of its ability to take and use?
4. Does using a SubjectToClimate lesson save you time and make it easier to teach about climate change?
5. Did integrating our materials that discuss climate change help you teach the subject/topics you were already going to cover?
6. How easy or difficult was it to use our materials to teach the subject/topics you were already going to cover?
7. What else would you need as an [insert grade band] teacher to integrate climate change into your classroom?
8. Why climate education?

Appendix H: Long-term Post-PD Survey

Background

1. Email
2. Name
3. In what state do you teach? (If you teach outside of the U.S., indicate the country and/or region.)
4. At what school do you teach?
5. Consent: Your responses will be anonymized and no personal identifying information will be shared along with your response. We will keep who you are confidential unless you explicitly give us permission. We will be using the aggregate data to analyze the effects of our teacher training modules, which will likely be published in an impact report. Do you consent for your responses to be used for research purposes? Mark only one oval.
    a. Yes
    b. No
6. Did you participate in a mentorship program? If so, please select your designation.
    a. Mentor
    b. Mentee
    c. NA
7. What barriers or challenges do you currently encounter in teaching about climate change?
    a. Climate change is not part of the mandatory curriculum
    b. Climate change is not relevant to my grade level or subject area
    c. Climate change is already covered in other subjects
    d. Climate change is too controversial and politically sensitive
    e. Difficulty in navigating climate emotions and conversations around environmental justice
    f. Lack of confidence in my knowledge of climate change
    g. Lack of prep time to prepare for climate lessons
    h. Lack of specialized professional development opportunities
    i. Need guidance on how to incorporate climate change into learning standards or curricula
    j. Need to be connected with a support system or network of climate educators
    k. Lack of climate education resources for my grade level or subject area
    l. Lack of evidence that climate change is a serious problem
    m. Lack of support from my local community
    n. Lack of support from school administration
    o. Shortage of class time to devote to the subject

Appendix H: Long-term Post-PD Survey

Section 1: Perspectives on Climate Change

1. How important is the issue of climate change to you personally?
    a. (1) Not at all important to (5) Extremely important
2. How much do you think climate change will negatively impact you personally?
    a. A great deal
    b. A moderate amount
    c. Only a little
    d. Not at all
    e. Don't know
3. How much do you think climate change will negatively impact future generations of people?
    a. A great deal
    b. A moderate amount
    c. Only a little
    d. Not at all
    e. Don't know
4. For each of the following statements please select your level of agreement. (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree)
    a. It is important for students to learn about climate change and its far-reaching impacts.
    b. Climate change education is an impactful form of climate action.
    c. Climate change is not only a significant factor in environmental health, but also in areas such as educational success, public health and economic prosperity.
    d. The data for climate change are ambiguous as to whether it actually occurs.
    e. Climate change is incapable of being scientifically tested and validated.
5. If desired, expand on your answer to the above statements.
    a. Write in

Section 2: Knowledge of Climate Change

1. How has the acquisition and development of knowledge in climate science and interdisciplinary climate topics impacted your teaching?
    a. Write in
2. For each of the following statements please select your level of agreement. (1 strongly disagree; 2 disagree; 3 neither agree nor disagree; 4 agree; 5 strongly agree)
    a. I feel confident in my knowledge of climate science.
    b. When teaching about climate topics, I feel confident in my ability to integrate the essentials of climate science.
    c. I am able to make seamless classroom connections between my subject and climate change.
    d. I ensure the accuracy of climate knowledge in my lesson plan designs.

Appendix H: Long-term Post-PD Survey

Section 3: Confidence in Teaching about Climate Change

1. How confident are you in teaching your students about climate change?
    a. Select number from a scale of (1) not at all confident to (10) completely confident
2. If desired, please explain your above response.
    a. Write in
3. Rate the current difficulty of integrating climate change into your classroom
    a. (1) extremely difficult to (5) extremely easy
4. If desired, please explain your above response.
    a. Write in
5. For each of the following statements please select your level of agreement. (1 strongly disagree; 2 disagree; 3 neither agree nor disagree; 4 agree; 5 strongly agree)
    a. I am satisfied with how I've been able to integrate climate topics into my grade level and subject.
    b. I have been able to implement a holistic, comprehensive approach to climate change education in my classroom.
    c. I have been able to integrate climate change topics into learning standards that I am required to cover in my classroom.
    d. I have productively covered climate change mitigation strategies with my students.
    e. I have engaged my students in discussions on local climate change topics.
    f. I have comprehensively incorporated climate justice into my climate change lessons.
    g. I can easily locate credible resources about climate change and integrate them into what I already teach.
    h. I use SubjectToClimate resources and/or lessons in my classroom to teach about climate change and meet required learning standards.
    i. I use resources and/or lessons from my state's Climate Change Education Hub in my classroom to teach about local climate topics that resonate with my students and their experiences. (if applicable)
    j. I am able to have open, validating conversations with my students about our climate emotions.
6. On a scale from 1 to 5, how supported do you currently feel in teaching about climate change? Support can refer to any outlet.
    a. (1) not at all supported to (5) fully supported
7. On a scale from 1 to 5, how prepared do you currently feel to teach about climate change?
    a. (1) not at all prepared to (5) highly prepared
8. Do you feel like you're achieving your goals regarding climate education?
    a. Write in

The following questions apply only if you have implemented SubjectToClimate materials in your classroom.

9. SubjectToClimate material was straightforward for me to implement as a teacher.
10. The Inquire-Investigate-Inspire lesson plan structure is logical and I would employ this method in my classroom going forward.

Appendix H: Long-term Post-PD Survey

Section 3: Confidence in Teaching about Climate Change

11. Regarding the SubjectToClimate materials you implemented—how likely are you to use these materials again?
    a. (1) not at all likely to (5) extremely likely or I already plan to use them again
12. While implementing the climate change resource(s) into your classroom, how would you rate the following? (Strongly disagree to strongly agree)
    a. Students were engaged in classroom learning/activities/discussion
    b. Students were more interested in climate change topics
    c. Students were more knowledgeable about climate change topics
    d. Students were able to apply critical thinking skills to class activities
    e. Students were interested in exploring the connection between climate change and their own academic or professional goals
    f. Students have exhibited more climate conscious behavior
    g. Students can identify specific career paths related to climate change that align with their interests
13. Would you like to elaborate on any of your responses above, or were there any other effects you noticed amongst your students during or after implementing SubjectToClimate's resource(s)?
    a. Optional write in
14. How has the use of SubjectToClimate materials impacted your planning and teaching process?
    a. Write in
15. If applicable, please list some specific resources you used and any comments you have on their effectiveness.
    a. Write in
16. How have you been integrating climate topics into your teaching? (Select all that apply)
    a. As a standalone activity like bell ringers, news articles etc.
    b. Integrated into other subjects like lesson and unit plans
    c. Through extracurricular activities or clubs
    d. Not currently integrating climate topics
    e. Other
17. If you selected "Other" please explain your response.
    a. Write in
18. How do you feel StC's support and training impacted your goals in climate education? What else might you need to get there?
    a. Write in

Appendix H: Long-term Post-PD Survey

Section 4: Frequency of Climate Change Education

1. How often do you discuss climate-related topics with your students? This can include brief or in-depth climate change connections.
    a. Daily
    b. 2-3 times a week
    c. Once a week
    d. 2-3 times a month
    e. Once a month
    f. 2-3 times a year
    g. Once a year
    h. Never
2. In the most recent school year, how many lessons have you taught or plan to teach that include topics related to climate change? This refers to one or more full class periods that incorporate climate change related topics into discipline content.
    a. Write in
3. How long does it usually take you to locate climate change content that you would use in your classroom?
    a. < 1 hour / 1–2 hours / 2–5 hours / 5–8 hours / 8–24 hours / multiple days or more
4. I am continuing to utilize and/or build on the action plan established during SubjectToClimate training to help me integrate climate change education into my classes. (1 strongly disagree; 2 disagree; 3 neither agree nor disagree; 4 agree; 5 strongly agree)
5. If desired, please expand on your answer to the above question.
    a. Write in
6. Do you feel you spend enough time teaching about climate change currently?
    a. Yes
    b. No
7. If desired, please expand on your answer to the above question.
    a. Write in

Appendix H: Long-term Post-PD Survey

Section 5: Closing

1. After accessing your state's Climate Education Hub, would you recommend it to other educators in your school/district/state? (if applicable)
    a. Yes
    b. No
2. If desired, please expand on your above answer.
    a. Write in
3. At this point, what else would you still need to teach about climate change more often?
    a. Greater confidence in my knowledge on the subject
    b. Guidance on how to incorporate it into standard curriculum
    c. Specialized professional development opportunities
    d. Ready-to-use climate education resources
    e. More engaging classroom materials on climate topics
    f. Resources on navigating climate emotions and conversations around environmental justice
    g. Prep time to prepare for climate lessons
    h. Class time to devote to the subject
    i. Connection to a support system of climate educators
    j. Support from my school's administration
    k. Support from my local community
    l. Other (write in)
4. If you selected "Other" please explain your response.
    a. Write in
5. Is there anything else you would like to share regarding your climate change teaching?
    a. Write in
6. Mentorship Program: The following questions only apply if you participated in the mentorship program, either as a mentor or a mentee.
    a. Do you feel this program provided long-term support for your goals in climate education?
        i. Write in
    b. Has participation in the mentorship program increased your confidence and capability to mentor and coach other teachers in climate change education? Why or why not?
        i. Write in

Appendix I: Teacher Feedback: Student Reach

1. Have you used a SubjectToClimate lesson, unit plan, or activity in your classroom?
    a. Yes
    b. No
2. Approximately how many total students engaged with those lesson plans, units, or activities?
    a. 1 – 25
    b. 26 – 50
    c. 51 – 75
    d. 76 – 100
    e. 101 – 150
    f. 151 – 200
    g. 200+
3. What grade level(s) did you use SubjectToClimate lessons, units, or activities with? Check all that apply.
    a. PreK – 2
    b. 3 – 5
    c. 6 – 8 / Middle School
    d. 9 – 12 / High School
    e. Other
4. What subject area(s) did the lesson, unit, or activity support? Check all that apply.
    a. English Language Arts
    b. Math
    c. Performing Arts
    d. Science, Engineering
    e. Social Studies, History
    f. World Language
    g. Other
5. Based on your observations, to what extent do you agree with the following statements about student outcomes after engaging with SubjectToClimate lessons, units, or activities? (Strongly agree, agree, disagree, strongly disagree)
    a. Students demonstrated increased interest in climate change and its impact on people and the planet
    b. Students showed a deeper understanding of climate change topics and/or solutions
    c. Students applied subject-area knowledge or skills to explore the causes or impacts of climate change on communities
    d. Students used critical thinking to evaluate climate-related issues
    e. Students expressed a greater sense of personal or collective responsibility to act on climate change
    f. Students expressed increased interest in potential career paths that contribute to climate solutions
    g. Students met key academic objectives and learning standards in the subject and grade level