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Building the Foundations: A Micro-credential Framework to Support Climate Resilience CTE Pathways in California Schools

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**Building the Foundations: A Micro-credential Framework to Support Climate
Resilience CTE Pathways in California Schools**

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Contents

Advisory Committee.....	
Acknowledgements.....	
Abstract.....	
1. Introduction.....	1
1.1 Background and Motivations.....	1
1.2 CTE In California.....	2
1.3 Golden State Pathways Program.....	3
1.4 Micro-credentialing.....	4
2. The Framework.....	5
2.1 Overview.....	5
2.2 Module 1 - Mechanisms.....	6
2.3 Module 2 - Strategies for Solutions.....	6
2.4 Module 3 - Local Opportunities.....	7
2.5 End of Course Assessment.....	8
3. Sample Framework Content.....	9
3.1 Module 1 - Scientific mechanisms of Climate Change.....	9
3.2 Module 2 Strategies for Solutions.....	12
3.3. Module 3 - Local Opportunities: Kendall-Frost Marsh Site Project.....	17
4. Discussion.....	20
4.1 Limitations.....	20
4.2 Future Implications.....	20
References.....	22
Appendix A.....	25
Appendix B.....	27

Abstract

Grant funding provided by California's Golden State Pathways Program provides the opportunity for public schools across California to implement a new career technical education pathway titled STEM Climate Resilience. This career technical education (CTE) pathway project outlines a structured program of study that integrates academic and technical coursework, industry-aligned curriculum, and career-focused skills. The transition to a green economy demands more experts than we currently have. CTE pathways in climate resilience and similar sectors are attempting to fill that gap by providing high school students with the knowledge and experience required to pursue college education in climate or to join the green workforce in a technical field. In K-12 STEM education, climate resilience is a concept that is relatively new and not yet well defined, resulting in schools and local educational agencies struggling to determine what knowledge and skills students in the pathway need to develop. This is where a micro-credential becomes essential. Rather than providing educators with a curriculum to follow word for word, a climate resilience micro-credential will equip educators with base knowledge of the physical science behind climate change, what mitigation and adaptation strategies are emerging, and what regional career opportunities are most promising in STEM fields related to climate resilience. This project outlines The Foundations Framework, an organizing principal for designing and implementing micro-credential programs to prepare educators for STEM climate resilience instruction.

1. Introduction

1.1 Background and Motivations

Climate education in a K-12 setting needs to be robust, comprehensive, and inspire students to strive for impactful climate careers. When our youth have limited opportunities to learn about climate change, they miss out on knowledge that is increasingly relevant to everyday life, which can, in turn, affect their preparedness for future careers and their ability to navigate a changing world as informed individuals. Beyond simply understanding that anthropogenic climate change is an issue, we must educate young people about how they can have a positive impact on this global challenge. It is crucial that students understand that climate careers are possible, viable options to pursue in their futures. Careers in climate take many forms, and as climate change progresses and economies begin transitioning to a green workforce, there exists a growing need for skilled labor in all sectors of climate. Estimates suggest the clean energy sector alone could generate more than six million new jobs in the next decade alone. (Rosen et al, 2024)

Definitions of climate jobs vary considerably. The National Oceanic and Atmospheric Association (NOAA) Climate Ready Workforce Initiative defines climate resilience careers as jobs that, “Reduce exposure, vulnerability, and risk to climate-related impacts; design, build, operate, maintain, and/or improve the infrastructure and systems (including nature-based systems) needed to reduce climate-related vulnerability and/or risk to people, assets, services, resources, ecosystems, or other attributes valued by individuals, businesses, communities, and/or governments” (NOAA, n.d) The Bureau of Labor Statistics identifies the following as commonly cited green career sectors: producing energy from renewable sources, improving energy efficiency, preventing and cleaning up pollution and greenhouse gases, and conserving natural resources. (Rosen 2024) Irrespective of the exact definition of a green job or climate job, preparing the next generations to step into these roles is vital for combating the climate crisis.

The transition to a green and blue economy demands more experts than we currently have. While secondary education provides public high school students with the knowledge and experience to pursue college education or to join the workforce in a technical field through career technical education pathways (CTE), there is not sufficient preparation for STEM climate careers through career technical education. The upcoming implementation of a new STEM Climate Resilience CTE pathway in high schools across California is a direct response to this. STEM Climate Resilience is defined in the education code as, “Science, technology, engineering, and mathematics pathways that also focus on climate resilience.” (California Legislature, 2022). Given this broad and somewhat vague definition and the interdisciplinary nature of resilience, the challenge facing many schools is how to define STEM Climate Resilience and perhaps more importantly, how to teach it. This project attempts to provide insight into the way educators supporting the STEM Climate Resilience pathway can be better prepared for the influx of new topics they will be expected to instruct.

1.2 CTE In California

Career Technical Education (CTE) pathways are defined by the California Department of Education as, “A program of study that involves a multiyear sequence of courses that integrates core academic knowledge with technical and occupational knowledge to provide students with a pathway to postsecondary education and careers.” (California Department of Education, n.d.) CTE typically includes hands-on learning experiences, career related credential earnings, and dual enrollment opportunities to earn college credits. (Rosen, 2024) Crucially, these pathways are intended to be aligned with the needs of local labor markets. The content of CTE pathways are determined by California State Model Curriculum Standards (MCS), which outline necessary skills and essential knowledge for a career in each pathway. Development of the standards is guided by recommendations of constituents from secondary and post-secondary education, business, and industry, and then aligned with Next Generation Science Standards and Common Core State Standards to ensure education standards across the state are equivalent. The California Department of Education is currently in the process of updating the state CTE Model Curriculum Standards to align with the nationally recognized Advance CTE framework. The National Career Clusters Framework developed by Advance CTE outlines fourteen career clusters, also called industry sectors, to be used as a shared structure for program design nationwide. (See Appendix A) Each cluster includes a sub-cluster, or a career area inside a given field. For example, Architecture and Civil Engineering is a sub-cluster under the Construction cluster. Each sub-cluster includes example programs of study, which are currently existing pathways that demonstrate alignment with a cluster and its sub-cluster. Climate Resilience is an example program of study under the Environmental Protection sub-cluster of the Energy & Natural Resources cluster.

The Energy and Natural Resources Cluster is defined as:

“Careers centered on regulating and managing the impacts of both natural processes and human activities, such as resource production and consumption. This Sub-Cluster involves developing and enforcing policies to protect all ecosystems, including space, air, land, and water, from natural disasters, pollution, and degradation. This field focuses on conserving natural habitats and biodiversity and applying scientific and engineering principles to solve environmental problems and improve climate resilience.” (Advance CTE, 2024)

The state of California has its own State Industry Sectors model, which is similar to the Advance CTE Framework, but not identical. (See Appendix A) California industry sectors list Agriculture and Natural Resources as well as Energy, Environment, and Utilities. As a result, STEM Climate Resilience is not included under current state standards. The previous iteration of California CTE MCS was adopted in 2013 and is currently undergoing updates to more closely align with the Advance CTE Framework. Updates to the California MCS to include the Energy

& Natural Resource sector, which houses Climate Resilience, will be proposed to the State Board of Education in November 2026.

1.3 Golden State Pathways Program

To address the growing need for green job employees, states have begun founding programs geared towards climate career preparation. In 2022, the California legislature enacted the Golden State Pathways Program Act (GSPPA) a state-wide effort to provide local educational agencies (LEAs) with the resources to support student advancement to college and careers in “high-wage, high-skill, high-growth” sectors. Establishment of the Golden State Pathways Program (GSPP) provides funding opportunities through consortium development and planning grants, as well as implementation grants. The law stipulates that the majority of funding, at least 85% of the total funds, be spent on implementation grants, which are, “to support a grant recipient’s ability to offer participating pupils high-quality college and career pathways opportunities.” (California Legislature, 2022). Priority consideration was given to “high-priority LEAs”, which refers to an LEA with higher than state average rates of dropout, suspension, or expulsion; child homelessness, foster youth, or justice-involved youth; or a lower than average rate of students completing all A–G California State and University of California required courses. (California Legislature, 2022)

The GSPPA allotted \$500 million total for the development of career and technical education pathways, with a focus on four high priority areas: education, computer science, healthcare and STEM climate resilience. (Rodriguez et al., 2024) Across California, seven schools from five separate LEAs received the grant to implement a STEM Climate Resilience pathway. Schools implementing STEM Climate Resilience and the associated LEA are presented in Table 1. Beyond the seven schools listed, many more received the grant to implement pathways in adjacent areas of study, including but not limited to: Environmental Engineering, Environmental Innovations, Natural Resources, Sustainability, Green STEM, etc. Although the environmental and sustainability pathways are similarly valuable to efforts of climate literacy and environmental education, this report will focus exclusively on the STEM Climate Resilience pathway.

Table 1

STEM Climate Resilience Pathway Implementation Schools and Grant Funding Results

High School	LEA	County	Funding Amount
Coronado	Coronado Unified School District	San Diego	\$784,229
Bolsa Grande	Garden Grove Unified School District	Orange	\$5,300,953
Santiago	Garden Grove Unified School District	Orange	\$5,300,953

Santa Ynez Valley Union	Santa Ynez Valley Union Unified School District	Santa Barbara	\$1,010,360
Twin Oaks	San Marcos Unified School District	San Diego	\$3,930,967

Note: Funding amount reflects the total awarded for all proposed pathways. Data for pathway implementation schools and grant funding were obtained from California Department of Education (n.d).

1.4 Micro-credentialing

Micro-credentials are short courses of study “with clearly defined learning outcomes, designed to recognize learners' existing skills, experience or knowledge at the same time and meeting industry demand.” (Scott et al. 2024, p. 2) These credentials provide targeted, flexible learning opportunities that can be completed in a shorter timeframe than traditional courses while offering meaningful recognition of specific, job-relevant competencies. Micro-credentialing originated in computer science to provide proof of competency and documentation of skills gained. It is common practice in the tech industry as well as in business and finance, but significantly less so in the education sector. The key difference between a micro-credential and a traditional professional development training is more than just the brief time frame. The goal of a micro-credential is to prove that hands-on learning towards a set of pre-determined competencies has been met. Upon completion, the awarded micro-credential certificate or badge must be granted via an accredited institution. This certificate signals that the participant has gained competencies in a specific area and can now demonstrate expertise in them.

In the context of professional development (PD) for educators, micro-credentials can be used to fulfill required PD hours, count towards accumulation of additional units, and maneuver participants up and around on the pay scale. (Scott et al. 2024) Teacher salaries are determined by how many years of experience the educator has, what level of degree they hold (bachelors, masters, doctorate), as well as additional units they have fulfilled. A teacher with 12 years of experience who holds a bachelor's degree plus 60 additional units in any subject receives a higher annual salary than a peer at the same level with no additional units. For newly credentialed teachers looking to begin their career, it may be beneficial to build up their degree and units early in order to set themselves up to be better positioned on the pay scale later on. Additionally, it is possible that having a micro-credential supporting an educator's subject credential could make them more marketable during the hiring process. Showing further learning and developed competencies speaks to an interest in teaching that content area and a stronger subject knowledge. A micro-credential cannot replace a traditional teaching credential, but it can further a teacher's specialization in one aspect of their profession.

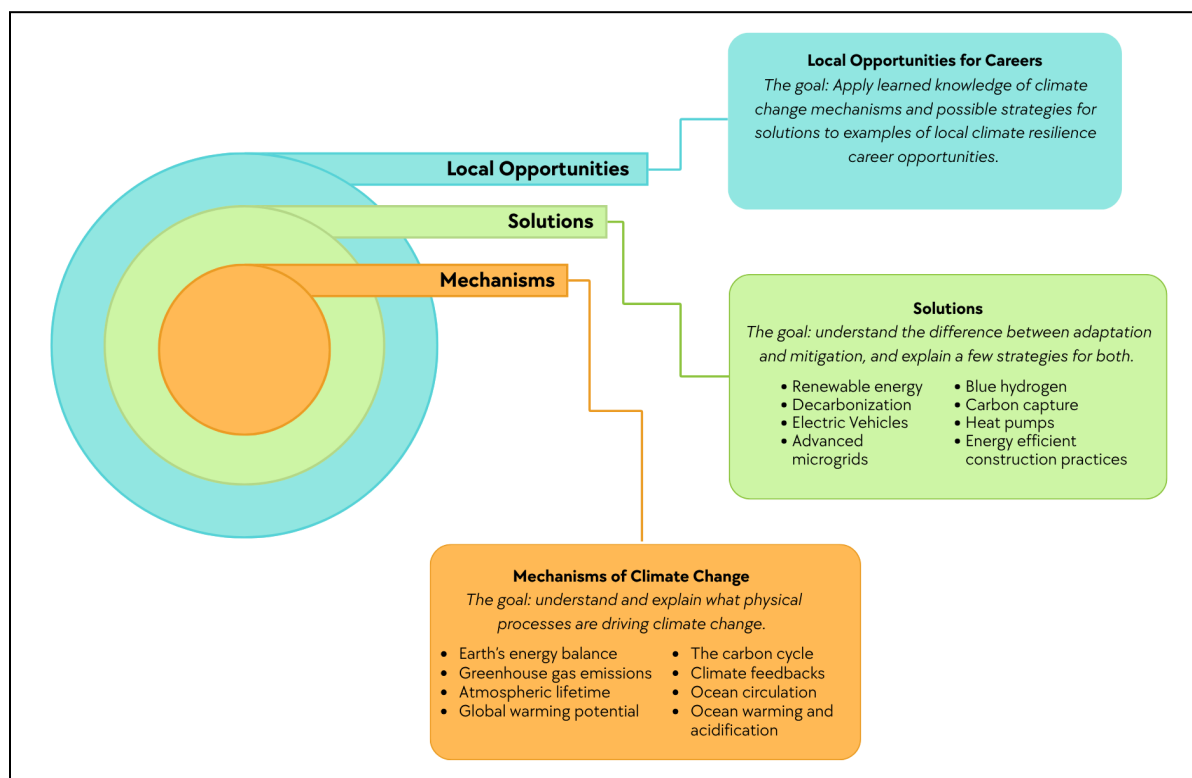
2. The Framework

2.1 Overview

The “Foundations Framework,” or “Foundations” is the name assigned to my organizing framework that guides STEM Climate Resilience micro-credential design and implementation. Foundations is first and foremost a tool intended to reduce barriers in implementing CTE STEM Climate Resilience. It is comprised of three nested circles, each intended to build on the previous. (See Figure 1: *The Foundations Framework*) Each circle is referred to as a Module. The design of this framework was heavily inspired by Advance CTE’s National Career Clusters, (see Appendix A) which also features a concentric circles design. The nested circle approach represents building upon prior knowledge and expanding on previous experiences as participants move through the program. Concentricity further represents an inability to separate the included topics. Both the problems and their solutions are intertwined. Understanding the challenge first is necessary to uncover the solutions and opportunities for intervention. Foundations is multidisciplinary by design; no one perspective or approach is the correct one. Essential to the design of this framework is its adaptability. Course content can be customized to reflect the needs of each cohort and regional site, while remaining flexible enough to adapt to emerging challenges and evolve alongside the STEM Climate Resilience Pathway.

Figure 1

The Foundations Framework



Note: Content of the modules is subject to change. (Henry, 2026)

It is assumed there is a foundational level of prior learning among educators. They have been exposed to climate science and possess basic working knowledge, but are not experts in the field. This model adopts a survey-based approach, providing a broad overview of multiple topics within the discipline. Each module encompasses a lecture-based portion to provide the background information needed to understand climate science concepts and processes, exploratory activities for participants to further develop understanding of the content, and example teacher resources for classroom instruction. (See Appendix B).

The Foundations Framework is designed to serve as a preliminary organizing principal for a potential future STEM Climate Resilience Micro-credential. This project is not intended to be a comprehensive step-by-step guide, but to act as an example of what something like this could look like should a Climate Resilience Micro-credential become available in the future. Modules can and should be adapted to fit the specific needs of each cohort. However, it is imperative that the five LEAs planning to implement the STEM Climate Resilience pathway collaborate to determine the competencies they intend to develop and end goals they wish to achieve. Despite being located in different regions, at different school sites, and with different governing LEAs, the Climate Resilience pathway and thus the ensuing micro-credential must follow a shared model. Developing this program without collaboration and a shared direction is counterproductive to the overarching goal to deliver comprehensive climate education to students.

2.2 Module 1 - Mechanisms

The goal: understand and explain what physical processes are driving climate change.

The first module investigates the scientific mechanisms of a changing climate. These mechanisms are based in the physical science of the enhanced greenhouse effect, controls on greenhouse gas (GHG) emissions, the carbon cycle, climate feedbacks, ocean circulation, warming and acidification, and future projections for Earth's climate system. Content should also cover climate modeling, not in practice, but as a general concept and a tool for understanding future Earth changes. The content of Module 1 should not vary from course to course, as it is intended to provide an overview of relevant background on the science behind climate change, and establish a base of understanding that will be built upon as the program progresses.

2.3 Module 2 - Strategies for Solutions

The goal: understand the difference between adaptation and mitigation, and explain a few strategies for both.

The second module focuses on strategies for solutions, encompassing both mitigation and adaptation methods. Module 2 can be tailored to align with specific industries or career sectors depending on LEA partnerships, regional climate challenges, and the local job market. There are near countless strategies for adapting to and mitigating the effects of climate change. Energy

technicians install and maintain clean energy systems; engineers design resilient infrastructure and energy technologies; ecologists and conservationists support habitat restoration; etc. In a coastal region such as San Diego, nature based strategies for adaptation solutions might emphasize coastal adaptation projects like living shorelines or wetland restoration. A more technical mitigation solution might include advanced microgrids and optimizing EV charging, to name a few. Solutions should highlight the scientific and technocratic ideas behind possible interventions, as well as the sociocultural considerations for implementing those solutions. The topics covered in Module 2 (see Figure 1) are simply examples of possible solution topics, they do not cover the extent of topics that can be addressed.

2.4 Module 3 - Local Opportunities

The goal: Apply learned knowledge of climate change mechanisms and possibilities for solutions to a regional example. Explore what important climate work is happening regionally, what are the career opportunities in that field, and what knowledge is needed for prospective employment in that area.

The third and last module focuses on regional opportunities in climate careers. Local and regional interventions are crucial to community adaptation and climate change mitigation. Here “Region” is defined as “a regional planning unit under California’s Unified Strategic Workforce Development Plan,” as it is used in the GSPPA. (California Legislature, 2022). This refers to the 15 geographic areas that serve as labor regions in California. Each Region acts as a network to align workforce opportunities within that community. (California Workforce Development Board, n.d.)

Of the three modules, Local Opportunities has the most room for flexibility in topic and activities, crucially involving site visits with community partners to facilitate hands-on experiences and emphasize the importance of making and retaining collaborative relationships and regional connections. This increases educator’s awareness of the possible climate resilience careers that students may wish to pursue. Refer to Figure 1 for examples of climate industry sectors.

Regardless of what kind of site visit or activities are chosen for this module, learned knowledge from Modules 1 and 2 should be applied. Content alignment throughout the process is critical. In our model, we use the example of educators from a San Diego County school site. In this example third module, the cohort will do a site visit to Kendall-Frost Marsh to investigate the importance of wetlands for climate mitigation and adaptation and explore related career pathways. Knowledge applied to this site visit includes carbon sinks and the carbon cycle; the importance of wetlands for emissions mitigation through carbon sequestration; the role wetlands play in adapting to flood risks; and ecosystem resilience.

2.5 End of Course Assessment

Micro-credential certificates are a formal recognition of learning, and as such require an assessment component to verify completion and ensure learning outcomes have been met. This framework includes three levels of assessment: formative, summative, and cumulative. Both formative and summative assessments are included in all three Modules, whereas the cumulative assessment is completed once at the end of the entire course.

The formative assessment is done at the beginning of each module, and takes the form of a brief activity to evaluate pre-existing knowledge and prepare individual learning goals for the remainder of the module. The goal of the formative assessment is to evaluate what participants already know about the topic, and where they may need additional support. In Module 3, the outlined formative assessment is a pre-learning quiz that asks participants to answer short questions on the carbon cycle and related wetland functions. Summative assessments are completed at the end of each module to recap learning for that content section. It is intended to answer the questions: What did you learn? How have you applied it today? How can you apply it in the classroom? The format of the summative assessment varies by module and facilitator, however it should be more robust than the formative assessment is. The summative assessment in Module 3 is a three-part public product graded with a rubric addressing content accuracy, evidence use, professional relevance, and communication quality.

The cumulative assessment is to be completed by participants at the conclusion of the course, after all three modules have been fulfilled. The Foundations Framework outlines multiple options for a cumulative assessment ranging from a content exam with applied short answer questions to design of a student-facing unit (see Appendix B). The assessment method used here is intentionally different from methods used for student assessment within the classroom. Course assessment as proposed here is simply a means to evaluate the following: was the necessary information communicated to you well, do you understand it, and can you effectively relay that information forward. As educators, participants in this course are well versed in student assessment requirements, it is therefore not necessary to utilize the same methods here. Regardless of the format the cumulative assessment takes, accreditors will share the information and expectations with participants at the onset of the course.

3. Sample Framework Content

3.1 Module 1 - Scientific mechanisms of Climate Change

Section 1: Framing the Instructional Goal and Success Criteria

Facilitator Notes:

Open by naming the purpose of the session: participants will not just review the science, but refine how to teach it across a coherent learning sequence. Emphasize that this module is designed to help learners answer one essential question: “What physical processes are driving climate change?”

Activity:

Quick-write and pair share: “Which part of this module do you think students will find most accessible? Which part will need the most support?” Participants share and identify one teaching challenge and one opportunity.

Section 2: Designing the Launch Sequence - Phenomenon, Energy Balance, and the Enhanced Greenhouse Effect

Facilitator Notes:

Model how the opening lessons should function as a concept-building arc.

Guide participants to notice the instructional logic:

- The anchoring phenomenon creates curiosity and a reason to learn.
- The energy balance model turns abstract numbers into visible system flow.
- The greenhouse effect lab provides a concrete explanation for heat retention.

Classroom Application Participants can Engage in:

- Ask open-ended questions before giving explanations.
- Use diagrams and simulations to reduce abstraction.
- Require students to label and explain models in their own words.
- Pair the lab with a CER response so students connect evidence to claims.

Activity:

Table task: Participants sequence three launch lessons on chart paper and annotate each with the main purpose, student product, and formative check. Then each group shares one instructional adjustment that would make the sequence clearer for students. The launch sequence should move students from noticing change to explaining energy flow and heat retention.

Section 3: Teaching Greenhouse Gases and Climate Feedbacks Through Student Ownership

Facilitator Notes:

Explain that the greenhouse gases jigsaw is designed to deepen content while building

communication skills. Emphasize that each gas should be studied through the same lens so students can compare them:

- Sources, both natural and human-caused
- Atmospheric lifetime
- Global Warming Potential
- Role in the climate system

Clarify teacher guidance for the jigsaw:

- Assign roles to keep groups focused.
- Provide a structured note catcher or comparison chart.
- Require each student to teach peers using accurate vocabulary.

Then transition to climate feedbacks. Explain that feedback instruction should not feel isolated. It should follow greenhouse gases because students need to see how warming is amplified through system responses.

Discuss the feedbacks:

- Water vapor feedback
- Ice-albedo feedback
- Cloud feedback

Activity:

Jigsaw planning and feedback loop practice. In pairs, participants design a short teacher script for one greenhouse gas and one feedback loop. Then they create a simple student-friendly anchor chart showing how to explain the process.

Section 4: Teaching Ocean Systems with Demonstrations and Data

Facilitator Notes:

Explain that ocean instruction should connect physical demonstration to data analysis. Start with the ocean circulation demonstration to build a concrete understanding of density, temperature, salinity, and heat movement. Clarify the instructional purpose:

- Surface currents are linked to wind.
- Deep currents are driven by density differences.
- Oceans move heat globally and vertically.
- Oceans slow atmospheric warming by storing heat.

Then show how the ocean warming and acidification lessons deepen understanding through evidence. Model how to use graphs and trends to support a CER response. Stress the importance of helping students move from “the ocean is changing” to “here is how we know and why it matters.”

Strategies to Emphasize:

- Use sentence frames for CER writing.
- Ask students to identify patterns before interpreting cause.
- Connect ocean warming and acidification back to atmospheric CO₂.
- Use one consistent data set across lessons when possible.

Activity:

Data-to-explanation routine. Participants examine sample ocean temperature, Keeling Curve, and ocean pH visuals. Working in triads, they draft one claim, one piece of evidence, and one reasoning statement that could be used in class.

Section 5: Climate Modeling, Concept Mapping, and Synthesis Instruction

Facilitator Notes:

Introduce climate modeling as the synthesis tool for the module. Explain that models help students test how the system responds to changing conditions. Make the distinction between simple models and more complex Earth system models clear for participants:

- Simple energy balance models help students understand core ideas.
- More complex models include atmosphere, ocean, vegetation, and chemistry.
- Spin-up, step change forcing, and gradual forcing help students understand how scientists test change over time.

Then move to synthesis instruction. Explain that concept mapping should be used after students have experienced energy balance, greenhouse gases, feedbacks, and ocean systems. The goal is to reveal relationships, not just vocabulary recall.

Activity:

Participants create a mini concept map connecting Earth's energy balance, greenhouse gases, feedbacks, and ocean processes. Then they revise the map to include one model idea, such as spin-up or step change forcing.

Section 6: Formative Assessment, Differentiation, and Pacing Adjustments

Facilitator Notes:

Review the assessment plan as a support system for learning, not an end-of-unit add-on. Explain how the formative checks should align to the instructional purpose of each lesson:

- Exit tickets for quick explanations
- Think–Pair–Share for reasoning and discussion
- Quick quizzes for vocabulary and concept checks
- CER writing for evidence-based explanation
- Concept maps for systems thinking

Then address differentiation and pacing. Use these teacher-facing adjustments:

- Visual learners: diagrams, simulations, labeled models
- Advanced learners: more discussion of climate modeling and scenario analysis
- Support learners: guided notes, sentence frames, vocabulary banks
- Shortened pacing: combine related days when time is limited
- Extended pacing: add climate modeling or a case study such as Arctic change

Emphasize that adjustment should preserve the learning goal, not remove the science.

Activity:

Participants choose one lesson from the sequence and identify one formative check plus one differentiation support. They then share how they would shorten or extend that lesson without losing rigor.

Section 7: Action Planning and Closing Commitment

Facilitator Notes:

Bring participants back to the larger purpose: preparing learners to explain the physical processes driving climate change. Ask them to reflect on what they will use first in their own setting.

Encourage practical next steps that fit their role, schedule, and learner needs.

Prompt participants to consider:

- Which activity will I implement first?
- Which teacher move will I strengthen?
- Which student misconception will I plan for?

Close by reminding participants that the module is strongest when each lesson is clearly connected to the next and each activity moves students closer to the essential question.

Activity:

Action plan exit ticket. Participants complete the following:

- One lesson I will adapt is...
- One support I will add is...
- One evidence-based explanation I want students to master is...

If time allows, ask participants to share one commitment with a partner.

3.2 Module 2 Strategies for Solutions

Section 1: Welcome, Purpose, and Prior Knowledge Activation

Welcome participants and frame the session around the goal of Module 2. Emphasize that the session will build a clear understanding of adaptation and mitigation, then move quickly into practical strategies, workforce connections, and classroom transfer.

Session Objectives:

- Define and distinguish adaptation and mitigation in the context of climate resilience

- Explain several strategies for adaptation and several strategies for mitigation
- Connect climate solution strategies to workforce roles in building, installation, operation, and maintenance
- Identify classroom-ready activities for application

Activity:

Quick write and turn-and-talk:

Prompt: “When you hear the words adaptation and mitigation, what comes to mind?”

Participants write for 1 minute, then discuss with a partner for 2 minutes. Use the final minute to collect 2–3 responses.

Classroom transfer: Ask participants to imagine how they would simplify this prompt for students in one sentence or one visual.

Section 2: Core Concepts — Adaptation vs. Mitigation

Explain the difference clearly and simply.

- Adaptation = actions that help people, systems, and places adjust to current or expected climate impacts
 - Mitigation = actions that reduce greenhouse gas emissions or increase carbon storage
- Clarify that some strategies do both. Nature-based solutions are a strong example because they can help communities adapt while also reducing emissions or storing carbon.
- Use a simple comparison: adaptation helps us live with the impacts of climate change; mitigation helps reduce the causes of climate change.
- Explain that educators can use sorting, sentence stems, or examples to help students remember the difference.

Activity:

Sort-and-justify challenge:

Show 4 examples and ask participants to decide “adaptation,” “mitigation,” or “both.”

Examples:

- Planting trees in cities
- Installing solar panels
- Restoring wetlands
- Raising coastal infrastructure

After each answer, ask one participant to give a one-sentence explanation.

Classroom transfer: Participants sketch a 3-column student sorting task: “Adaptation / Mitigation / Both.”

Section 3: Adaptation Strategies in Practice and Classroom Application

Introduce a few high-value adaptation strategies and explain why they matter. Keep the focus on practical application and regional variation.

Examples of strategies to cover:

- Blue-green infrastructure: parks, trees, green roofs, green walls, ponds, lakes, streams, and rivers used together with urban water infrastructure. Explain that this can reduce urban heat, lower particulate matter pollution such as PM 2.5, support urban animal populations and migratory species, and improve human health outcomes.
- Increasing surface albedo: making surfaces more reflective, such as painting roofs or pavement lighter colors, to reduce heat buildup and urban heat island effects.
- Coastal resilience: use of dunes, native vegetation, wetlands, floodplains, and in some regions oyster reefs to buffer storm surge, reduce flooding, and protect coastlines. Emphasize that solutions depend on local geography and regional conditions.
- Afforestation and reforestation: increasing tree canopy cover; reforestation returns trees to historically forested areas, while afforestation creates forest on non-forested or degraded land.

Note that nature-based solutions are often both adaptation and mitigation.

Activity:

Small-group strategy match:

Each table receives 4 strategy names and 4 short impact statements. Groups match each strategy to its likely benefit, then identify whether it is adaptation, mitigation, or both.

Suggested impact statements:

- Reduces urban heat
- Buffers storm surge
- Stores carbon
- Lowers energy use for cooling

Reconvene for a quick debrief.

Classroom transfer: Ask participants to redesign the activity for students as a card sort, gallery walk, or notebook sort with simple icons.

Section 4: Mitigation Strategies in Practice and Career Connections

Transition to mitigation and connect the strategies to workforce pathways.

Facilitator Notes:

Connecting climate solutions to careers is imperative for determining the specific skills that should be taught within a STEM CTE pathway, as each solution area directly aligns with workforce demands and career preparation. Aligning instruction with these roles ensures that

students develop relevant, applied skills that prepare them to contribute meaningfully to climate resilience efforts.

Examples of strategies to cover:

- Decarbonization: reducing carbon emissions across systems and sectors
 - Renewable energy: use solar as a clear example of shifting from fossil fuels to low-carbon energy
 - Wetlands restoration and rewilding salt marshes: explain that these are nature-based solutions that store carbon while also protecting ecosystems
- Reinforce that many mitigation strategies require people across roles to move from planning to implementation.

Connect solutions to careers:

- Energy technicians install and maintain clean energy systems
- Engineers design infrastructure and energy systems
- Ecologists and conservationists support habitat and ecosystem restoration
- Natural resource managers coordinate land and water use
- Educators build public understanding and career awareness
- Data analysts track emissions, temperatures, and outcomes
- Geospatial analysts map risk, site conditions, and solution placement

Activity:

Workforce mapping and classroom design sprint:

In pairs, participants choose one strategy and answer:

1. Who would help build it?
2. Who would help install it?
3. Who would help operate or maintain it?
4. Who would monitor whether it works?

Then ask each pair to turn that conversation into a student-ready task:

- a quick-write prompt
- a role-play
- a matching activity
- a “who does what?” career map

Invite 2–3 pairs to share both the workforce connection and the classroom version.

Classroom transfer: Encourage participants to use the same structure with students, such as “Match the solution to the career.”

Section 5: Synthesis, Reflection, and Immediate Action Step

Bring the session together by reinforcing the main message: adaptation and mitigation are different, but both are necessary, and many strategies sit at the intersection. Invite participants to reflect on how this content can support Module 2 and their broader teaching or facilitation work. Ask participants to choose one activity they can use right away with students and one strategy they want to teach more deeply.

Activity:

Exit ticket and implementation plan:

Participants complete one sentence for each prompt:

- “One adaptation strategy I can teach is ____.”
- “One mitigation strategy I can teach is ____.”
- “One classroom activity I can use immediately is ____.”
- “One career connected to these solutions is ____.”

Then ask them to name the first time they could use the activity in class or in their program.

Section 6: Decarbonization and Nature-Based Mitigation Solutions

Purpose:

Help educators understand key mitigation strategies, including decarbonization and nature-based solutions, with a focus on wetland protection and restoration.

Facilitator Notes:

Introduce mitigation as the set of strategies that reduce greenhouse gas emissions or increase carbon storage. Then move into two important categories: decarbonization and nature-based solutions.

Key Content to Include:

Decarbonization

Decarbonization takes renewable energy a step further. Beyond methods for generating electricity, decarbonization strategies also include making energy use more efficient. For example, enhancing the lifetime of electric vehicle batteries, making buildings more energy efficient, powering public transportation with clean and renewable energy, and so on.

Decarbonization also includes removing excess carbon dioxide from the atmosphere via carbon capture technologies. While this is relatively new technology, and still being heavily researched, carbon removal is critical to meeting global net zero emissions targets and reducing the most extreme impacts of climate change.

Nature-Based Solutions

Nature-based solutions for mitigation are projects that protect, manage, and restore natural environments in order to store carbon and reduce GHG emissions.

Wetland Protection and Restoration

Wetlands sequester carbon at higher rates per unit area than terrestrial ecosystems do, and therefore are disproportionately responsible for carbon sequestration worldwide. Wetlands are considered “edge” ecosystems, meaning they occur at the transition between a completely flooded area and a dry land area. In more recent years we have begun to understand the importance of wetlands for their “ability to cleanse water by trapping pollutants, sequester carbon, maintaining high levels of biodiversity, and more.” Wetlands are fantastic at sequestering carbon because the soil and sediment is largely anaerobic, meaning it does not have oxygen. Organisms that live in these conditions use carbon, rather than oxygen, to sustain their lives, thus capturing it deep into the ground.

Activity:

Strategy Sort and Talk

Provide educators with 3 cards or prompts:

- Decarbonization
- Nature-based solutions
- Wetland protection and restoration

Ask participants to:

1. Sort each strategy as a mitigation strategy
2. Discuss one example of how it works
3. Identify one career role connected to each strategy, such as engineer, energy technician, ecologist, or natural resource manager

Classroom Transfer:

Ask educators to adapt the same sort for students using:

- Picture cards
- Sentence stems
- A simple “What does it do?” chart

Suggested Closing Prompt (summative assessment):

“What is one mitigation strategy from today that you could teach using a simple sort, discussion, or case study?”

3.3. Module 3 - Local Opportunities: Kendall-Frost Marsh Site Project

Essential Question:

How can restoring and protecting local wetlands like Kendall-Frost Marsh reduce climate risk and create regional career pathways in climate resilience?

Real-world Context:

Cohort will investigate Kendall-Frost Mission Bay Marsh — a UC Natural Reserve System site used for research, education, and habitat protection. Participants connect classroom knowledge (carbon cycle, carbon sinks, ecosystem services, coastal resilience) to local mitigation/adaptation efforts, current research projects, and regional labor market opportunities (research technician, restoration specialist, environmental educator, GIS analyst, coastal engineer).

In-depth Inquiry:

Teams research:

- Wetland functions (carbon sequestration, biodiversity, water filtration)
- Local/region-specific climate risks (sea-level rise, storm surge, flood frequency)
- Ongoing research at Kendall-Frost and partners (UCSD, local NGOs)
- Skills/credentials required for related careers. Inquiry includes pre-visit literature review, data collection during the site visit (observations, simple water/vegetation metrics, photos, interviews with staff), and post-visit investigation of local job postings/training programs.

Participant Voice and Choice:

Participants choose an investigation focus (ecology, carbon accounting, community engagement, education/outreach, career pathways). They select the format of the public product (research brief + poster, community presentation, short documentary, curricular mini-unit, or a career pathway guide for CTE participants).

Reflection:

Structured reflective prompts at three points: pre-visit (expectations and research questions), during (field journals, observational notes tied to learning goals), and post-visit (what changed, implications for teaching/CTE). Reflections linked to professional practice: How will this knowledge influence your classroom, CTE pathway advising, or curriculum design?

Critique and Revision:

Peer critique workshops use a rubric aligned to scientific reasoning and professional applicability. Faculty and community partners (reserve staff, UC Extension) provide feedback. Participants iterate: revise data interpretation, tighten messaging for intended audience, and refine career guidance components.

Public Product:

Each team produces a three-part submission:

- Site report (mission/purpose of site, activities completed)
- Evidence-based analysis (observations, application of carbon cycle and carbon sink concepts, implications for mitigation/adaptation)

- CTE application (how findings translate to classroom pathways and local career opportunities). Products are presented at a public forum (school/partner event) and submitted to UC San Diego Extension as part of micro-credential evidence.

Collaboration:

Small interdisciplinary teams pair science-focused learners with educators/CTE-focused peers. Community partner liaisons (reserve staff, local NGOs) mentor teams. Roles rotate (team lead, data manager, community liaison, communications lead) to build transferable skills.

Teacher Facilitation:

Educator designs scaffolds (prep reading, data sheets, interview protocols), models CER-style evidence use, schedules partner communications, and supports connections to regional career resources.

Interdisciplinary Connection:

- Science (ecosystems, carbon cycling, climate impacts)
- Math (data analysis, modeling sequestration estimates)
- English (technical writing, presentations)
- CTE/Career Development (credential mapping, local labor market research)
- Social Studies (policy/land use)
- Art/Media (public outreach materials)

Assessment:

- Formative: pre/post quizzes on carbon cycle and wetland functions; observation checklists during visit; peer critiques using rubric.
- Summative: three-part public product graded with a rubric addressing content accuracy, evidence use (CER-style), professional relevance (CTE application), communication quality, and revision responsiveness.
- Provide answer key/expectations to participants.

4. Discussion

4.1 Limitations

Current available literature on micro-credential use is focused on the role of micro-credentials in higher education (college students) and workforce development for sectors like the tech industry or finance. As a result, there is some uncertainty about the role of micro-credentialing for professional development in education. Sara Weisman notes that, “hard conclusions about the value of micro-credentials are impossible to draw, given there are so many that are relatively new.” (2024) While there are some who argue against the application of certificate programs for teacher development, it is not accurate to say that certification programs cannot work. (Scott et al. 2024) As micro-credentialing becomes a more common practice for professional development in the education field, greater information will be available on the use of these programs and best practices.

Furthermore, the required courses for completing the STEM Climate Resilience CTE pathway have not yet been made publicly available. This raises questions about the specific content to be included in the micro-credential, and how it will be tailored to fit within the CTE requirements once they have been announced. It is expected that this framework will be adjusted as time progresses, and adopting institutions are encouraged to modify the framework and its content to fit their needs. More information will be available following the updates to California State CTE MCS in November 2026, at which point this framework will likely need to be re-evaluated and updated to align more closely with the new standards. This does not change the overall goal of this micro-credential, which is to provide quality education and support to teachers involved in STEM Climate Resilience pathways.

4.2 Future Implications

While each LEA and individual school may have differing implementation plans for their pathway, collaboration between implementing LEAs is crucial. We expect some levels of content variability in both the CTE pathway and micro-credential program due to regional labor market demands and school site specific partnerships. Foundations is intended to serve as a flexible model that can be adopted and adapted by K–12 educators as the CTE pathway continues to evolve and become more defined. While implementation may vary across contexts, the overarching goal of advancing comprehensive climate literacy practices remains consistent statewide. Maintaining this shared focus is essential to the framework’s use, ensuring that the STEM Climate Resilience pathway remains cohesive in its approach and effective in supporting meaningful, positive student learning outcomes. At minimum, there will need to be continuity amongst the accrediting institutions that offer this program. This could suggest that only one accrediting institution should be the designated facilitator for all six involved LEA’s, or alternatively, that accrediting institutions will need to work jointly to finalize content matter and program execution.

The Foundations Framework is an organizing principle based in three modules exploring

climate science, climate solutions, and what careers in climate resilience look like. Foundations was constructed to support the creation of a micro-credential for the educators involved in California's new STEM Climate Resilience CTE. I believe Foundations will serve as a jumping off point to continue the conversation around enhancing climate literacy and climate career-readiness in K-12 education, as well as reduce barriers to implementing climate resilience pathways on a larger scale. This framework is centered around STEM (science, technology, engineering, and math) climate careers due to the limitations posed by the pathway category and GSPP grant qualifications. In a future where climate career pathways are the norm, this framework and others should be expanded even further to include a more holistic understanding of what STEM pathways in climate resilience can be. Ideally, these pathways will grow to encompass careers in the social sciences and humanities, art, public health, and many more. Every career can be a climate career.

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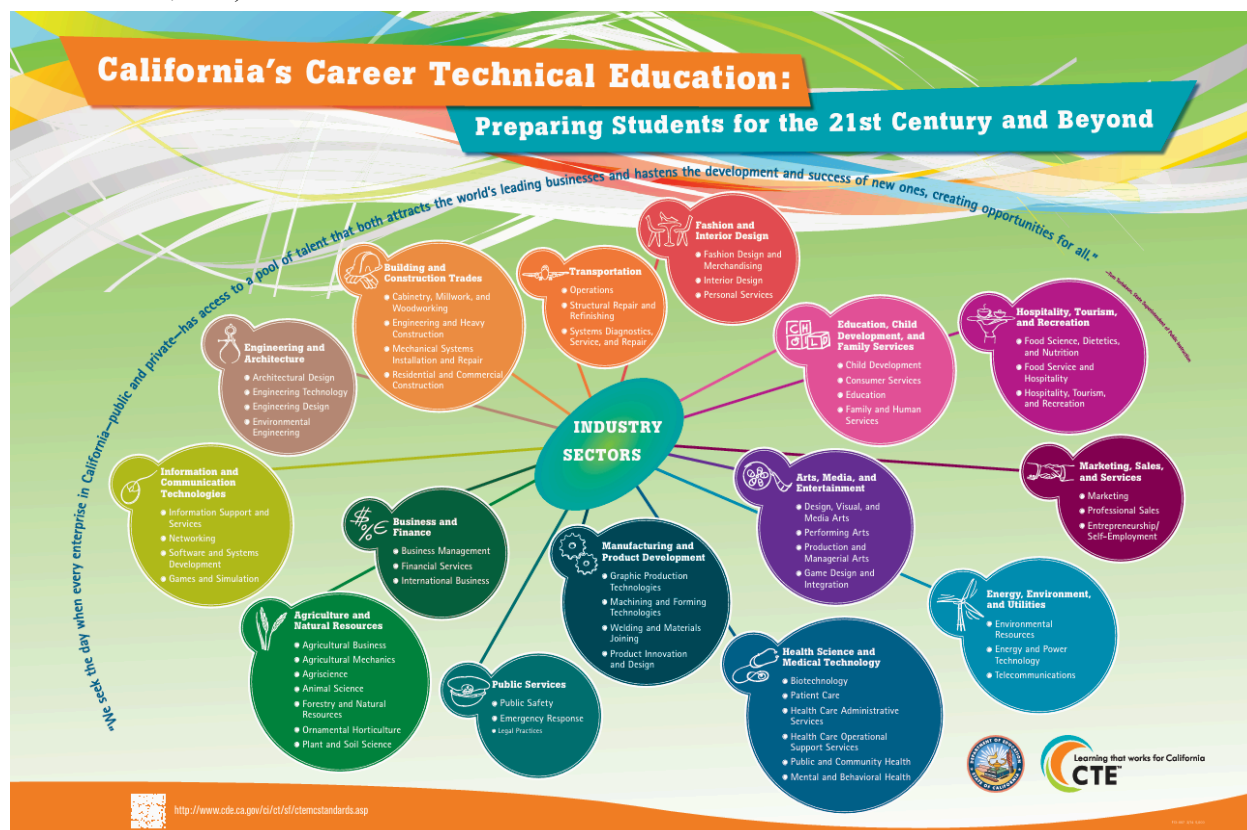
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Career-Ready Practices

Cross-Cutting Clusters

- Accounting
- Banking & Credit
- Financial Strategy & Investments
- Insurance
- Real Estate
- Business Information Management
- Entrepreneurship & Small Business
- Leadership & Operations
- Project Management
- Regulation
- Data Science & AI
- Network Systems & Cybersecurity
- IT Support & Services
- Software Solutions
- Unmanned Vehicle Technology
- Web & Cloud
- Marketing & Advertising
- Market Research, Analytics, & Ethics
- Retail & Customer Experience
- Strategic Sales
- Digital Technology
- Management & Entrepreneurship
- Investing in the Future
- Financial Services
- Arts, Entertainment, & Design
- Hospitality, Events, & Tourism
- Supply Chain & Transportation
- Advanced Manufacturing
- Construction
- Energy & Natural Resources
- Agriculture
- Public Service & Safety
- Healthcare & Human Services
- Education
- Early Childhood Development
- Education Administration & Leadership
- Learner Support & Community Engagement
- Teaching, Training, & Facilitation
- Behavioral & Mental Health
- Biotechnology Research & Development
- Community & Social Services
- Health Data & Administration
- Personal Care Services
- Physical Health
- Military & National Security
- Local, State, & Federal Services
- Judicial Systems
- Emergency Response
- Water Systems
- Plant Systems
- Food Science & Processing
- Animal Systems
- Agricultural Technology & Automation
- Agribusiness
- Utilities
- Resource Extraction
- Environmental Protection
- Ecological Research & Development
- Conservation & Land Management
- Clean & Alternative Energy
- Skilled Trades
- Equipment Operation & Maintenance
- Construction Planning & Development
- Architecture & Civil Engineering
- Safety & Quality Assurance
- Robotics
- Production & Automation
- Industrial Machinery
- Engineering
- Purchasing & Warehousing
- Planning & Logistics
- Marine Transportation
- Maintenance & Repair
- Ground & Rail Transportation
- Air & Space Transportation
- Travel & Leisure
- Culinary & Food Services
- Conferences & Events
- Accommodations
- Performing Arts
- Media Production & Broadcasting
- Lighting & Sound Technology
- Fine Arts
- Fashion & Interiors
- Design & Digital Arts

Figure A2: California Career Technical Education State Industry Sectors (California Department of Education, n.d.)



Appendix B

Teacher Resource Samples

BI: Module 1 Implementation: Example of Classroom Application

1. Anchoring Phenomenon (Engage)

Activity:

- Show students a **time-lapse visualization** (Arctic ice loss, global temperature anomaly map, or ocean heat content graph).
- Ask:
 - *“What patterns do you notice?”*
 - *“What could be causing these changes?”*

Purpose:

- Activates prior knowledge
- Builds curiosity and ownership
- Sets up the essential question:
 - *What physical processes are driving climate change?*

2. Interactive Energy Balance Model (Explore)

Activity:

- Students build a **simple energy balance diagram/model**:
 - Incoming solar radiation (340 W/m²)
 - Reflected energy (~100 W/m²)
 - Absorbed energy (~235 W/m²)
- Use:
 - Whiteboards OR digital simulations (PhET, NASA tools, Modtran)

Extension:

- Have students simulate increased greenhouse gases and observe:
 - More energy trapped
 - Less outgoing radiation

Purpose:

- Makes abstract numbers tangible
- Reinforces conservation of energy
- Builds systems thinking

3. Mini-Lab: The Greenhouse Effect (Explain)

Activity:

- Two containers experiment:
 - One with normal air
 - One enriched with CO₂ (ex: baking soda + vinegar setup)
- Place under lamp → measure temperature changes

Student Task:

- Collect data
- Graph temperature over time
- Draw conclusions

Discussion prompts:

- *How did CO₂ affect heat retention?*
- *How does this relate to Earth's atmosphere?*

Purpose:

- Builds causal reasoning
- Connects model → real-world system
- Supports NGSS science practices

4. Jigsaw on Greenhouse Gases (Elaborate)

Activity: Divide students into groups to research:

- Carbon dioxide
- Methane
- Nitrous oxide
- Water vapor

Each group investigates:

- Sources (natural + human)
- Atmospheric lifetime
- Global Warming Potential (GWP)

Then re-group so each student teaches others.

Output:

- Class comparison chart
- Quick presentations

Purpose:

- Promotes student ownership of content
- Reinforces communication skills
- Builds connections between gases and impacts

5. Climate Feedback Simulation (Explore/Explain)

Activity:

- Use diagrams or simulations to illustrate:
 - Water vapor feedback
 - Ice-albedo feedback
 - Cloud feedback

Student Task:

- Create a **feedback loop diagram** showing:
 - Cause → effect → amplification

Example:

Warming → Ice melts → Lower albedo → More absorption → More warming

Extension:

- Ask: *“Which feedback do you think is most impactful and why?”*

Purpose:

- Helps students understand non-linear systems
- Develops analytical thinking

6. Ocean Circulation Demonstration (Explore)

Activity:

- Density experiment:
 - Warm vs cold water (food coloring)
 - Salt vs freshwater layering

Goal:

- Show thermohaline circulation principles

Discussion:

- *How does ocean circulation move heat globally?*
- *Why do oceans slow climate change?*

Purpose:

- Builds understanding of vertical and horizontal heat transfer

7. Data Analysis: Ocean Warming & Acidification (Elaborate)

Activity:

- Students analyze:
 - Ocean temperature graphs
 - Keeling Curve (CO₂ levels)
 - Ocean pH trends

Task:

- Identify trends
- Write a **Claim-Evidence-Reasoning (CER)** explanation

Example Prompt: *How is increasing atmospheric CO₂ affecting ocean chemistry?*

Purpose:

- Strengthens scientific argumentation
- Connects abstract mechanisms to measurable data

8. Concept Mapping (Synthesize)

Activity: Students create a **concept map** connecting:

- Energy balance
- Greenhouse gases
- Feedback loops
- Ocean processes

Requirement:

- Include arrows + labeled relationships

Purpose:

- Encourages systems-level thinking
- Reveals misconceptions

9. Formative Assessments Throughout

Examples:

- Exit tickets:
 - “*Explain the greenhouse effect in 2–3 sentences*”
- Quick quizzes (concept checks)
- Think–Pair–Share questions

10. Final Performance Task (Evaluate)

Task options:

- Create an **explainer video or infographic** answering: *What physical mechanisms are driving climate change?*

Must include:

- Energy balance
- Greenhouse gases
- At least one feedback
- Ocean role

Rubric focuses on:

- Accuracy
- Systems thinking
- Evidence use

Key Instructional Strategies Embedded

- Inquiry-based learning
- Phenomenon-driven instruction
- Modeling & simulations
- Collaborative structures
- Data analysis & CER
- Systems thinking
- Real-world applications

Differentiation Ideas

- Visual learners → diagrams, simulations
- Advanced students → climate modeling discussions
- Support learners → guided notes + sentence frames

B2: Cumulative Assessment Possibilities

1. Portfolio + Reflective Narrative

- Components: curated set of artifacts from each module (pre/post assessments, CER pieces, lesson/unit drafts, field data snapshots, partner interview summaries, student public products) + a reflective narrative.
- Purpose: Demonstrates cumulative content mastery (climate mechanisms, mitigation/adaptation strategies, local interventions), pedagogical choices, and plans for classroom/CTE integration.
- Assessment focus: Evidence use, alignment to learning goals, reflection on impact and next steps, professional growth.
- Grading notes: Use a rubric with strands for Content Accuracy, Instructional Design, Evidence of Impact, and Professional Application.

2. Site Project Plan — Applied Local Intervention (performance task)

- Components: A site-specific project plan (e.g., a classroom-community partnership with a local wetland, coastal resilience lesson sequence, or schoolyard carbon/biodiversity audit) including needs analysis, objectives, timeline, stakeholder plan, assessment strategy, and budget/resources. Include an implementation brief.
- Purpose: Synthesizes all modules: mechanisms (science base), solutions (mitigation/adaptation strategies and technologies), and local opportunities (community partners, careers, logistics).
- Assessment focus: Feasibility, scientific accuracy, integration of pedagogy and career-readiness, measurable student outcomes, and community engagement plan.

3. Evidence-Based Teaching Artifact Set (modular evidentiary tasks)

- Components: For each module, submit one strong artifact plus a short rationale:
 - Mechanisms: Mini-lesson + student pre/post task showing conceptual growth (e.g., concept map comparison, CER scores).
 - Strategies for Solutions: Inquiry lab or modeling task + student data analysis artifact.
 - Local Opportunities: Site-visit report + student-facing career-pathway activity or community outreach piece.
- Purpose: Show iterative instructional practice and student learning across modules.
- Assessment focus: Quality of student artifacts, teacher commentary on modifications, and alignment to standards/learning targets.

4. Student-Facing Unit Design + Assessment Suite

- Components: A 2–3 week unit for secondary students that sequences Module content, a set of student assessments (formative probes, CER prompts, summative performance

task), and exemplars with scoring guides. Include alignment to standards and reflection on classroom implementation.

- Purpose: Demonstrates curriculum design competence and assessment literacy in climate science and CTE linkage.
- Assessment focus: Coherence across lessons, assessment validity, differentiation, and evidence of student learning embedded.

5. Skills & Career Pathway Mapping Portfolio (CTE emphasis)

- Components: A mapped set of local/regional climate careers tied to curricular units, including competency matrices (skills, courses, certifications), sample student pathways, and partner contacts for internships/apprenticeships.
- Purpose: Shows readiness to integrate workforce development with climate science instruction.
- Assessment focus: Alignment to local labor market, curricular integration, and actionable steps for student entry into pathways.

6. Cumulative Knowledge Assessment (content exam + applied short answers)

- Components: An assessment with content items covering climate mechanisms, mitigation/adaptation methods, and local application scenarios. Include applied short-answer prompts requiring a CER-style response and one local implementation planning question.
- Purpose: Verifies conceptual mastery and ability to apply knowledge under timed conditions.
- Assessment focus: Accuracy, evidence use, reasoning, and practical planning skills.

7. Reflection + Growth Plan with Evidence of Implementation

- Components: Reflective portfolio detailing one implemented classroom intervention derived from the micro-credential (with student work samples, assessment results, and stakeholder feedback), plus a 1-year growth plan describing how the educator will expand climate instruction and measure impact.
- Purpose: Demonstrates sustained integration and professional growth beyond course completion.
- Assessment focus: Measured student impact, iterative improvement, and realistic goals with indicators.