

Solar Energy & Heat Transfer in Greenhouses – Unit Plan Duration: 5 days, 50–60 minutes each; artifacts saved daily (graphs, CERs, models, prototype images).

Anchoring Phenomenon

Why does a greenhouse heat differently from its surrounding environment? This question frames all five lessons and is referenced explicitly in each opening and closure to maintain coherence across investigations, modeling, and engineering tasks (Georgia Standards of Excellence, S6E4.b; NGSS MS-PS3-3). (Georgia Standards of Excellence [GSE], n.d.; NGSS Lead States, 2013)

Central Focus

This unit centers on understanding how solar energy drives heat transfer through radiation, conduction, and convection, and how these processes influence greenhouse efficiency and sustainability. Students will investigate heating rates of soil, water, and air, analyze data, and develop models to explain energy flow within greenhouse systems. These experiences are significant because heat transfer underpins Earth’s weather and climate patterns and informs real-world engineering solutions for energy efficiency. The unit aligns with Georgia Standards of Excellence S6E4.b (Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates) and NGSS MS-PS3-3 (Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer). Interdisciplinary connections strengthen learning: students apply ELA literacy standards (RST.6-8.7) by integrating multiple sources in Claim-Evidence-Reasoning writing, use mathematics to graph

temperature data and calculate rates of change, and leverage technology through PhET simulations and digital modeling tools. These cross-disciplinary tasks deepen conceptual understanding, foster critical thinking, and prepare students to connect science learning to sustainability challenges in their communities.

In this unit, students will plan and carry out investigations, analyze data, and develop models to illustrate how radiation, conduction, and convection interact in a greenhouse environment. They will also design and test a device that maximizes or minimizes thermal energy transfer, applying scientific principles to real-world challenges.

This aligns with the Georgia Standards of Excellence: S6E4.b – Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates. It also supports NGSS performance expectations:

MS-PS3-3 – Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (Georgia Department of Education, n.d.; NGSS Lead States, 2013)

Lesson activities connect to other disciplines such as: ELA/Literacy: Students use Claim-Evidence-Reasoning (CER) writing and structured discourse to explain findings, meeting standards like RST.6-8.7 (integrate multiple sources of information in diverse formats). Math: Students create and interpret graphs of temperature data, calculate rates of change, and compare patterns.

Technology: Students use PhET simulations and digital tools for modeling and data visualization. (NASA Climate Kids, n.d.; PhET, n.d.; NOAA JetStream, n.d.) By the end of the unit, students will understand how solar energy impacts ecosystems and human-designed systems, and how scientific and engineering practices can address sustainability challenges.

The central focus of Lesson 1 is understanding how solar energy drives heat transfer and identifying the three modes—radiation, conduction, and convection. This is important because these processes explain how energy moves through Earth’s systems and influence greenhouse efficiency, climate, and everyday experiences. In this lesson, students will observe demonstrations and analyze examples to predict how different materials (soil, water, air) respond to sunlight. They will connect these ideas to the greenhouse phenomenon and begin building foundational knowledge for planning investigations. This is in alignment with the curriculum standard: S6E4.b – Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates. (Georgia Department of Education, n.d.)

Lesson 1 will provide students with an overview of how solar energy interacts with matter and will set the stage for deeper inquiry in subsequent lessons. The central focus of this lesson also connects to other disciplinary topic areas such as ELA/Literacy through the following standard: RST.6-8.7 – Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) to address a question or solve a problem.

The central focus of Lesson 2 is the planning and execution of a controlled investigation to compare temperature changes in soil, water, and air inside and outside a greenhouse model. This is important because it allows students to collect real data and analyze patterns of heat absorption and transfer. Students will design fair tests, measure temperature changes, and graph data to understand how different materials respond to solar energy. This lesson emphasizes scientific practices and prepares students for modeling and explanation.

This aligns with S6E4.b and supports NGSS MS-PS3-4 – Plan an investigation to determine the relationships among the energy transferred, type of matter, mass, and the change in the average kinetic energy. (Georgia Department of Education, n.d.; NGSS Lead States, 2013) The central focus of Lesson 3 is to analyze data from the investigation and construct explanations for observed differences in heating rates. Students will develop and use models to illustrate how radiation, conduction, and convection interact in a greenhouse system. This is important because modeling and explanation deepen conceptual understanding and help students connect evidence to scientific principles. Students will engage in CER writing and visual modeling to communicate their findings. This aligns with S6E4.b and supports NGSS MS-PS3-5 – Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (*Next Generation Science Standards*, NGSS Lead States, 2013; Georgia Standards of Excellence, S6E4.b) The central focus of Lesson 4 is to apply scientific principles by designing, building, and testing a device—such as a solar oven or insulation prototype—that optimizes thermal energy transfer. This is important because it links science to practical problem solving and sustainable solutions. Students will use data to justify design choices and engage in argument from evidence. This lesson emphasizes creativity, critical thinking, and engineering practices. This aligns with NGSS MS-PS3-3 – Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (*NGSS Lead States*, 2013, MS-PS3-3)

Lesson 5: Synthesis, Reflection & Assessment The central focus of Lesson 5 is synthesizing learning by presenting findings, comparing models, and reflecting on how solar energy and heat transfer relate to sustainability and everyday life. This is important because it reinforces connections to lived experiences and prepares students for future units on climate and energy. Students will demonstrate mastery through a summative quiz and written reflection, and they will engage in discourse to connect scientific concepts to real-world applications. This aligns with S6E4.b and literacy standards for integrating information and constructing evidence-based explanations. (Georgia Standards of Excellence, S6E4.b)

Connecting Lived Experiences, Cultural Resources, and School Resources: Linking Students’ Lives to the Historically Responsive Literacy Framework.

This unit is grounded in the belief that education is not just about academic content but about affirming humanity and creating spaces of dignity and possibility. Students’ daily lives and cultural resources are integrated throughout the lessons to make learning relevant and justice centered. Heat transfer concepts are connected to familiar experiences—such as clothing choices, cooking, HVAC systems, and car interiors—while extending to community issues like food deserts in marginalized neighborhoods. These discussions empower students to see science as a tool for equity, sustainability, and social transformation. The unit uses school gardens, greenhouses, and composting programs to demonstrate the conversion of food scraps into nutrient-rich soil, creating a circular system that reduces waste and promotes local food production. Students explore how STEM tools, including drones and sensors, can monitor greenhouse conditions and optimize growth, linking technology to real-world problem solving rather than passive use. This approach

reflects the principles of Critical Race Techno-Pedagogy by positioning technology as a means for justice rather than reinforcing inequities. Family stories and community observations are incorporated into discourse and reflection, honoring students' cultural knowledge and lived realities. These practices align with abolitionist and culturally responsive frameworks, ensuring that Black and Brown students are not only included but empowered. By integrating science into social justice, sustainability, and school-based innovation, the unit transforms classrooms into homeplaces of resistance and possibility, where students' voices, histories, and futures are centered. This vision draws on the work of Muhammad (2023) and her Historically Responsive Literacy framework, Bettina Love's (2019) call for abolitionist teaching and freedom dreaming, and Paulo Freire's (2018) emphasis on dialogue and critical consciousness. Together, these theorists remind me that teaching is the pursuit of humanity and liberation, and that culturally responsive education must center joy, intellect, skills, identities, and criticality while challenging systems of oppression. The unit connects science learning to students lived experiences and cultural contexts and incorporates the five pursuits from Muhammad's HRL framework. Students begin by relating heat transfer to familiar experiences such as home heating and cooling, standing in shade versus sun, cooking, and observing greenhouse foods in local markets. As Muhammad reminds us, "When we teach with identity at the center, we help students see themselves in the learning and affirm who they are" (Unearthing Joy, p. 42). These identity connections ensure that students recognize their place in the scientific narrative. Students also develop essential skills by collecting, graphing, and interpreting temperature data, building and testing solar devices, and using Claim-Evidence-Reasoning writing to explain their findings. Muhammad emphasizes that "Skills are not just about doing; they are about doing with purpose and excellence" (p. 58), which guides the design of hands-on investigations and engineering challenges in this unit. (Muhammad, 2023) (Love, 2019)

Intellectual engagement is fostered as students reason with evidence about radiation, conduction, and convection, compare materials and media, and apply scientific principles to real-world challenges. As Muhammad states, “Intellect is cultivated when students engage in deep thinking and inquiry that matters to their lives” (p. 73). These opportunities for analysis and modeling deepen conceptual understanding while connecting to authentic contexts. (Muhammad, 2023)

Criticality is addressed through discussions about who has access to green food systems and energy-efficient technologies, as well as explorations of equity and sustainability. Students examine food deserts in marginalized communities and consider how greenhouse innovation can serve as a solution. Muhammad writes, “Criticality means teaching students to question injustice and imagine new possibilities for freedom” (p. 91), and this unit positions science as a tool for social transformation. Finally, joy is embedded throughout the learning experience. Students engage in choice-based projects such as solar oven challenges and mini-greenhouse builds, celebrate peer successes, and participate in interactive games. Muhammad reminds us that “Joy is not an add-on; it is the heartbeat of learning. It is what makes education humanizing” (p. 12). By centering joy alongside identity, skills, intellect, and criticality, this unit creates a classroom environment that is culturally responsive, justice-oriented, and deeply connected to students’ lives. (Muhammad, 2023)

Misconceptions

A common misconception in Lesson 1 is the belief that the Sun’s heat travels through air by conduction. Students often confuse conduction with radiation since both involve heat transfer. To clarify, solar energy reaches Earth primarily by radiation, not conduction. Conduction occurs only when matter is in direct contact, such as soil in contact with a pot.

Teachers should use a visual model showing radiation traveling through space and conduction occurring between solids. During the opening discussion, the teacher should ask questions such as: If space is mostly empty, how could conduction happen? What does radiation allow energy to do that conduction cannot? Can you think of an example where conduction happens? These prompts foster reasoning and help students understand that radiation is the main way energy moves from the Sun to Earth.”

A common misconception in Lesson 2 is that water always warms faster than soil. Students assume this based on experiences like warm bathwater or pools. Water has a higher specific heat capacity than soil, so it warms more slowly under equal conditions. Students will investigate by comparing equal masses of soil and water under identical sunlight while recording and graphing temperature changes.

During analysis, the teacher should ask: Which material changed temperature faster and why? If water warms faster, why do oceans stay cooler than land during summer? What does this tell us about how water and soil store heat? These questions help students understand the role of specific heat and to correct their misconceptions.

A common misconception in Lesson 3 is the idea that dark colors create heat. Students often equate heat with color absorption without realizing colors do not generate energy—they only affect absorption and reflection of radiation. Teachers should emphasize that dark colors absorb more radiation, while light colors reflect it, but neither creates heat. Students will analyze data and use Claim-Evidence-Reasoning to explain why black surfaces feel warmer than white ones. The teacher should ask: Does the color make heat or absorb energy? Why do black surfaces feel warmer than white ones under the same light? What role does radiation play in this observation? These prompts reinforce the concept of energy absorption rather than energy creation.

A misconception in Lesson 4 is that greenhouses warm only because air is trapped. Students often oversimplify greenhouse heating as insulation, ignoring radiative trapping and reduced convection. Teachers should model energy flow in a greenhouse, showing how sunlight enters, heat is absorbed, and infrared radiation is retained. Students will design and test devices to maximize or minimize heat transfer. During planning, the teacher should ask: What happens if we open the vents? How does convection affect the temperature inside the greenhouse? Why is radiation important in greenhouse heating? These prompts help students understand that greenhouse warming involves radiation, absorption, and controlled airflow. Addressing Misconceptions: To correct the belief that the Sun's heat travels by conduction, students will analyze a visual model showing radiation through space and conduction only in solids. For the misconception that water heats faster than soil, students will graph temperature changes and compare slopes to reveal specific heat differences. To address the idea that dark colors create heat, students will use CER writing to explain that colors absorb energy rather than generate it. Each misconception will be revisited during synthesis discussions and modeled through guiding questions. Lesson 5 focuses on synthesis and reflection. By this point, some students may still believe heat transfer is a single process or may confuse

energy sources with energy generation. Some believe the Sun creates heat in objects directly rather than transferring energy through radiation. Teachers should reinforce that the Sun is Earth’s primary energy source and that heat transfer takes place through radiation, conduction, and convection in various contexts. During review and reflection, the teacher should ask: Which process explains sunlight warming Earth? Which process explains why the pot heats on a stove?

How do radiation, conduction, and convection work together in everyday life? These prompts help students connect all three modes of heat transfer and apply them to real-world examples.

Differentiation

Below is a differentiated plan for your six-week solar energy and heat transfer unit that aligns with Universal Design for Learning (UDL) and addresses the needs of multilingual learners and the 10+ students with IEPs, severe behavior disorders, ADHD, medication plans, and literacy challenges in your 6th-grade classes. Each activity is written in paragraph form, avoids bullet points, and integrates multilingual supports, flexible outputs, scaffolds, and extensions. The design choices are grounded in CAST’s UDL Guidelines and current school-based intervention research for ADHD and special education accessibility. (CAST, 2018) To reduce language barriers and enhance conceptual understanding, each lesson begins with a bilingual mini-glossary and a visually rich overview. Key terms—such as *radiation*, *conduction*, *convection*, *specific heat*, *absorption*, *reflection*, and *greenhouse effect*—are presented in both English and students’ home languages, accompanied by concise definitions, labeled diagrams, and sentence frames for Claim-Evidence-Reasoning (CER). Students may co-create the glossary during notetaking, and captions are projected while short video clips or

simulations are displayed. This approach expands opportunities for representation and language clarification and aligns with Universal Design for Learning (UDL) checkpoints that emphasize multiple means of representation and vocabulary support. Multilingual glossaries with visuals and sentence frames are recommended strategies for English language learners and reflect CAST guidelines on perception and language supports (CAST, 2018; AVID Open Access, n.d.; Colorín Colorado, n.d.; University of Minnesota, n.d.).

To provide flexible options for lab reporting, students may submit their heating-rate investigation as a video lab report, a poster featuring photographs of the experimental setup and temperature graphs, or a typed document. An oral recording option is also available for students who experience challenges with writing fluency; however, all formats must include Claim-Evidence-Reasoning (CER) elements embedded through sentence frames. Offering multiple modalities for action and expression aligns with the Universal Design for Learning (UDL) principle of varying how students demonstrate understanding and reduces barriers for learners with ADHD and literacy challenges by enabling them to plan and organize responses in accessible ways (CAST, 2018; National Association of Elementary School Principals [NAESP], n.d.; University of Minnesota, n.d.).

To scaffold data analysis, pre-filled data tables with time intervals and instrument names will be provided, along with graph templates that include predetermined axes and scales. During laboratory activities, students will rotate through roles such as lead investigator, data recorder, safety officer, and presenter, using role cards that clearly define responsibilities. These scaffolds reduce cognitive load related to executive functioning and enhance clarity of syntax and structure, which UDL identifies as essential for learners with variability in attention and processing. Role rotation also promotes positive group participation for students with behavioral plans by

establishing predictable tasks and accountability (CAST, 2018; University of Minnesota, n.d.; University of Arizona Global Campus, n.d.).

For students with IEPs and ADHD, incorporate organizational training courses directly into the lesson flow. Provide a visual agenda, time reminders on a projected timer, color-coded bins for materials, and a two-minute “stop and check” routine where students confirm they have the thermometer, data table, and labeling done before collecting readings. The CDC summarizes classroom strategies shown to help ADHD learners, including behavioral classroom management and organizational training; pairing visual schedules, clear routines, and reward systems with UDL design reduces the need for later accommodations by making the environment predictable and accessible. (CAST, 2018; Centers for Disease Control and Prevention [CDC], 2025)

To support behavior regulation during hands-on work, implement a simple daily report card that tracks on-task behaviors during lab stations and provides immediate feedback and earned choices for the final expression format. Evidence reviews of middle school ADHD interventions emphasize that consistent, teacher-administered behavior supports, executive function coaching, and school-based programs increase task engagement when implemented with fidelity. Your report card can be brief, rubric-based, and tied to lab safety and data completion, complementing the UDL goal of purposeful, motivated learners. [mdpi.com] (CAST, 2018)

For accessibility in the lab space, swap glassware with plastic wherever feasible, declutter lab tables to only essentials, and ensure aisles are wide enough for safe movement. Provide adjustable-height or seated workstations for students with mobility or health needs, and explicitly model safety protocols for diverse sensory profiles. These universal design moves in science labs proactively reduce

barriers before accommodations are needed and mirror recommendations from accessibility guidance for precollege science labs.

(ConnSense Report, n.d.; National Science Teaching Association [NSTA], n.d.)

For multilingual and literacy supports during concept introduction and synthesis, add captions to all videos and provide short transcripts of teacher demonstrations, along with pictorial concept maps of energy pathways. UDL checkpoints endorse alternatives for auditory information and visuals that clarify structure; using captions and transcripts supports recognition networks for learners who process language differently, while concept maps strengthen understanding of how radiation, conduction, and convection connect in real contexts. [equella.uagc.edu] (CAST, 2018).

To extend learning for gifted and highly ready students, offer a variable-control mini-study where they plan and justify changes to one independent variable, such as material color or container insulation, and present an optimization proposal to the class. This extension preserves common goals while increasing challenge and autonomy, which the updated UDL Guidelines encourage through options that sustain engagement and foster expert learning dispositions. The focus on identity and learner agency in version 3.0 supports this approach. [avidopenaccess.org] (CAST, 2018)

For students with significant reading challenges or those whose IEPs specify alternative assessment, replace extended written responses with performance tasks and an oral defense. In a structured interview, students explain their setup, interpret their graph, and justify their claim using the CER frames. UDL's multiple means of action and expression validate oral demonstrations and

performance-based assessments; special education resources also stress that well-designed alternatives should maintain the same standards while changing the mode of response. (CAST, 2018; University of Minnesota, n.d.; Care Options for Kids, n.d.)

To promote self-regulation and reduce escalation for students with behavior disorders, embed predictable “cool-down” options tied to the lab routine, such as a pre-designated reflection seat and a two-minute breathing or metacognitive prompt about what step comes next. Special education intervention packets and ADHD classroom guidance recommend proactive environmental supports, preferential seating, and brief regulation breaks to prevent behavior spirals; within UDL, these belong to engagement supports that sustain effort and persistence. (CAST, 2018; College of William & Mary, n.d.; Centers for Disease Control and Prevention [CDC], n.d.)

To address executive function gaps common in ADHD, integrate a “materials passport” checklist on the lab table and a quick peer verification before starting each trial. Research syntheses for middle school ADHD interventions highlight the importance of organizational routines and checklists to scaffold planning and working memory, which you can embed universally in the lab instructions, so they serve all learners without singling out students with IEPs. [mdpi.com]

To close lessons with reflection for all learners, conduct a short “think aloud” modeling how to connect evidence to claims, then invite students to record a one-minute audio reflection explaining which heat transfer mode was observed and why. Captioned audio with a text summary supports recognition networks and gives students with literacy challenges a low-barrier way to demonstrate

understanding that still requires precise reasoning, which aligns with UDL recommendations to vary expression while maintaining rigor. (CAST, 2018)

To leverage your advanced critical thinkers as catalysts for class wide learning, each lab and modeling task now includes an optional scholar-lead pathway. In this pathway, honor students plan micro-studies that isolate a single variable beyond the core procedure, such as altering container geometry to test convective mixing or using calibrated light sensors to quantify radiant flux at different distances. They write a short investigation brief that states the refined question, predicted outcome grounded in prior evidence, and an outline of controls. During data collection, they mentor peers by demonstrating how to verify instrument calibration and how to record with precision, which raises the overall quality of evidence while meeting UDL goals for collaborative engagement and multiple means of action and expression. At synthesis, these students present optimization proposals that argue for design changes in greenhouses or solar devices, defending trade-offs among radiation absorption, conductive pathways, and convective airflow. This structure gives advanced learners authentic challenge without removing core access for others, since the base lab remains intact and fully scaffolded. In analysis-heavy lessons, honor students receive an enriched data set that includes noise, outliers, and mixed units to encourage critical treatment of measurement reliability, unit conversion, and error propagation. They practice claim-evidence-reasoning at a higher level by comparing their class dataset to a reference pattern they derive from a simple heat capacity model. They must articulate whether their evidence supports, refutes, or refines the initial claim, and they are tasked with proposing a follow-up test that would increase confidence. Less experienced readers work with the standard, cleaned template and receive explicit modeling of graph interpretation, while advanced students deepen the investigation by designing the next iteration. This nested approach keeps

expectations aligned to common standards while opening a ceiling for advanced thinking. For discourse, each concept introduction closes with a brief teacher think-aloud and then shifts into a structured seminar where honor students take on the role of discussion anchors. In Lesson 1, they lead reasoning on why conduction cannot operate across a vacuum and probe classmates' explanations until they distinguish energy transfer by radiation from particle-to-particle contact. In Lesson 2, they challenge the intuitive "water heats faster" belief by connecting ocean-lag phenomena to specific heat capacity and thermal inertia, using classmates' graphs as evidence. In Lesson 3, they frame the color question as an energy accounting problem, guiding peers to separate energy absorption from energy creation and to trace energy pathways from source to surface to re-radiation. This intentional discourse structure raises the cognitive demand while honoring multilingual learners and students with ADHD through clear sentence frames, visuals, and predictable turn-taking. (CAST, 2018)

For engineering design, advanced students act as lead designers who integrate constraints and criteria more formally. They draft a short design memo that quantifies the target performance (for example, reaching a specified internal temperature within a time window while keeping peak temperature below a safety threshold). They model energy flow qualitatively with arrows and quantitatively with simple rate statements, then iterate the design in response to test data. Meanwhile, students who need additional structure follow the baseline build with pre-measured materials and a checklist that focuses attention and keeps sequencing clear. By running both pathways in parallel, the class benefits from elevated modeling and rigorous iteration without sacrificing clarity or safety. In reflection, advanced students record a brief "expert commentary" that synthesizes how radiation, conduction, and convection interacted in the day's task and proposes a real-world application, such as urban heat island mitigation or passive solar design

improvements. Students with reading and writing challenges use the oral recording option with captioning and a visual storyboard to express the same conceptual understanding. Keeping a shared rubric ensures the same standards for evidence and reasoning while allowing different modalities. In management and support, honor students are invited to serve as peer coaches for organization during labs, using a materials passport to help groups verify readiness before measurements begin. This does not substitute for your behavior supports and daily report card routines; rather, it adds a positive leadership layer that can improve on-task rates without singling out any student. The environment continues to include bilingual glossaries, captions, transcripts, role cards, pre-filled tables, graph templates, and multiple output choices for lab reports, so your ten advanced students experience appropriately complex work while your ten or more students with IEPs, ADHD, severe behavior disorders, medication needs, and literacy struggles have consistent access and predictability.

Inclusive Discourse Framework

Discourse in this unit is intentionally designed as the engine for sense-making and as a space for belonging and justice. Grounded in Bettina Love’s abolitionist teaching, this section emphasizes that science learning is an act of love and respect—“Si te amo y respeto, me amo y respeto yo” (Love, 2019, p. 105). (Love, 2019)

Teachers model language that affirms identity and agency: “Abolitionist teaching is the practice of working in solidarity with communities of color while drawing on the imagination, creativity, refusal, (re)membering, visionary thinking, healing, rebellious spirit, boldness, determination, and subversiveness of abolitionists to eradicate injustice in and outside schools” (Love, 2019, p. 2).

This framing reminds students that science learning is not only about mastering content but about envisioning justice and freedom through inquiry. These moves align with Bettina Love’s vision of education as a practice of freedom, ensuring that students experience science not only as content but as a tool for justice and joy. (Love, 2019)

From the opening lesson, students engage in dialogue that connects heat transfer to real-world contexts such as home heating, food systems, and sustainability. These connections affirm that science intersects with equity and community well-being. On Day 1, discourse begins with predictions about why greenhouses warm faster than the surrounding air and why soil, water, and air heat at different rates. These predictions become the foundation for collaborative exchanges where students use academic language supported by sentence stems like “I agree because…” and “Can you clarify…?” This early emphasis on structured talk moves establishes norms for evidence-based discussion and nurtures a classroom culture grounded in respect and shared responsibility.

As students transition into investigation on Day 2, discourse shifts toward coordinating observations and negotiating experimental design. Teams assume defined roles—lead investigator, data recorder, safety officer, and presenter—to ensure equitable participation. Guiding questions such as “Where is radiation happening in our setup?” and “What variable did we unintentionally change?” sustain purposeful talk and invite students to reason about systems and patterns. Public thinking routines, including posting group graphs on a shared data wall and conducting gallery walks with “I notice/I wonder” prompts, transform individual observations into collective evidence.

Day 3 deepens discourse through analysis and explanation. Students participate in graph talks, moving from describing patterns to interpreting mechanisms and connecting findings to the anchoring phenomenon. They construct explanations using the Claim–Evidence–Reasoning framework and develop models that depict energy pathways in the greenhouse. Peer feedback sessions encourage critique and revision, reinforcing the idea that scientific understanding emerges through argumentation and collaboration. These exchanges are layered to help students scale reasoning from micro-level observations to macro-level concepts such as Earth’s energy budget.

By Day 4, discourse becomes design oriented. Students present engineering solutions aimed at maximizing or minimizing thermal transfer, justify choices with empirical data, and respond to peer challenges. This phase introduces argument from evidence as a central practice, prompting students to defend design decisions and propose tests that could falsify their claims. Finally, Day 5 synthesizes learning through presentations, review games, and reflective writing that ties scientific principles to lived experiences and issues of equity and sustainability. Students compare models, evaluate design strategies, and articulate actionable ideas for energy efficiency in their communities, closing the loop between classroom inquiry and real-world application.

Vocabulary integration is essential for meaningful discourse. Students develop fluency with key scientific terms—radiation, conduction, convection, albedo, energy transfer, and greenhouse effect—through authentic use in talk and writing. Teachers embed vocabulary in sentence stems and guiding questions, such as “How does convection occur in your greenhouse model?” and “What evidence shows radiation as the dominant transfer?” A Vocabulary + Discourse Wall displays terms alongside student-generated

examples, reinforcing academic language in context. These strategies ensure that multilingual learners and students from nondominant communities' access and apply scientific language as part of collaborative sense-making.

Throughout the unit, discourse is framed as an inclusive practice that honors multiple ways of knowing. Students are invited to share cultural perspectives on energy use, food access, and environmental stewardship. Teachers model language that affirms identity and agency, ensuring that every learner experience science not only as content but as a tool for justice, sustainability, and joy.

Assessment Alignment & Evidence of Processes/Products

Assessment in this five-day unit is intentionally woven into instruction to capture both how students do science (processes) and what they produce (artifacts), aligned to S6E4.b and NGSS MS-PS3-3. Daily formative checks—such as exit tickets, observation charts, and draft graphs—show processes like planning investigations, collecting data, and analyzing patterns, while producing artifacts including data tables, graphs, and CER statements. These formative tasks align with objectives by reinforcing understanding of radiation, conduction, and convection and supporting students in constructing evidence-based explanations. Summative assessments extend these practices: the Investigation Report demonstrates the process of planning and analyzing a fair test and results in a written report with tables, graphs, and CER reasoning; the Energy Pathways Model captures the process of developing and using models and produces a labeled physical or digital model with justification; the Design Prototype & Presentation reflects the engineering design process—planning, building, testing, and revising—and results in a functional prototype and a data-driven presentation; and the Unit Quiz + Reflection synthesizes learning through argument from evidence and produces a written reflection connecting heat transfer to

sustainability and equity. Each assessment explicitly links objectives and standards by requiring students to plan and carry out investigations, analyze data, develop models, and apply scientific principles to real-world challenges. (Georgia Standards of Excellence, S6E4.b) (NGSS Lead States, 2013; MS-PS3-3) Formative assessments (e.g., heating-rate investigation, CER writing, graph analysis) directly measure objectives such as identifying heat transfer modes and analyzing energy flow. Summative assessments (design challenge, energy pathway model, unit quiz) extend these objectives by requiring application of scientific principles to real-world problems. Both assessment types align with standards S6E4.b and NGSS MS-PS3-3 by integrating investigation, modeling, and argument from evidence.

Connection to Next Unit:

Data from heating-rate investigations and greenhouse models will guide reteaching of heat transfer concepts for students needing support and enrichment for advanced learners in the upcoming weather unit. Prior graphs and CER statements will serve as entry points for exploring how unequal heating drives atmospheric circulation and microclimates, ensuring coherence across units.

Using Outcomes to Design the Next Unit

Student outcomes from these datasets and greenhouse energy-transfer models—will directly inform the design of the next unit on local weather and microclimates. These artifacts provide a foundation for exploring how unequal heating of Earth’s surface drives atmospheric circulation, convection currents, and microclimate variations. This progression aligns with Georgia Standards of

Excellence S6E4.a (explain how unequal heating causes weather patterns and winds) and S6E4.c (analyze how solar energy drives atmospheric circulation and influences climate zones). (Georgia Standards of Excellence, S6E4.b)

Prior graphs and models will be revisited to predict how surface properties such as soil, water, and vegetation affect local temperature and wind patterns. These predictions will serve as an entry point for investigations into albedo, urban heat islands, and energy budgets. By leveraging existing data, students will see continuity between units and deepen their understanding of how energy transfer connects to weather systems.

Instructional decisions will be data-driven: group mastery patterns will determine reteaching needs for heat transfer concepts and enrichment opportunities for advanced learners. Students who need additional support will engage in targeted reviews of conduction, convection, and radiation before applying these ideas to atmospheric processes. Those demonstrating mastery will extend learning through enrichment tasks such as modeling microclimates or analyzing climate resilience strategies.

This approach ensures coherence across units, strengthens three-dimensional learning (DCIs, SEPs, CCCs), and promotes equity by tailoring instruction to student performance.

Materials, Tech & Safety

This unit requires materials such as clear plastic bins or mini-greenhouse kits, thermometers including infrared thermometers, soil, water, air probes, lamps for indoor setups, black and white boards for albedo demonstrations, data sheets, graph paper, and computers or tablets for PhET simulations. Personal protective equipment such as safety goggles, heat-resistant gloves, and UV-blocking shields

is mandatory for lamp and UV demonstrations, while optional tools include micro-drones or temperature loggers for advanced data collection. General safety protocols always emphasize supervising heat lamps, avoiding direct UV exposure, managing cords to eliminate trip hazards, and ensuring hydration and sun safety during outdoor activities. Drone use requires administrative approval and a designated safety perimeter. When working with greenhouse models, heat sources must be monitored closely to prevent burns or overheating, and proper ventilation should be maintained to avoid excessive humidity and mold growth. Vermicomposting introduces biological risks such as microbes, spores, and allergens; therefore, bins should be kept in well-ventilated areas, preferably outdoors or in a greenhouse, moisture control should be maintained, and meat, dairy, or oily foods should never be added. Gloves and masks, preferably N95 for sensitive individuals, must be worn when handling compost, and hands should be washed thoroughly afterward. Ventilation guidelines include drilling small holes in bin sides and lids for airflow, covering holes with mesh to prevent pests, and elevating bins slightly for circulation. Airtight containers should be avoided because oxygen is essential for aerobic decomposition, and indoors, fans or vent hoods should be used to maintain airflow and reduce humidity. Risk mitigation involves using only plant-based scraps, maintaining proper moisture and aeration, keeping bins covered but ventilated, wearing PPE during handling, posting clear safety signage, and providing virtual or sealed kits for high-risk students. Additional science lab safety requirements aligned with NSTA Safety Standards and Flinn Scientific Guidance (Palcik, 2021) include wearing ANSI-approved goggles for all heat, chemical, or UV demonstrations, never leaving lamps or hot plates unattended while using heat-resistant mats under equipment, following SDS protocols for fertilizers or soil amendments and storing chemicals in labeled containers, inspecting cords for damage and keeping liquids away from electrical devices, posting evacuation routes and ensuring fire extinguishers and first-aid kits are accessible,

reviewing emergency procedures before labs, enforcing behavioral expectations such as no horseplay and requiring lab contracts signed by students and guardians, composting only approved materials and disposing of non-compostable waste according to school policy, and ensuring accessibility by keeping aisles clear, providing adjustable-height workstations, and substituting glassware with plastic when possible. (NASA Climate Kids, n.d.; PhET, n.d.; NOAA JetStream, n.d.)

APA REFERENCES:

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

Freire, P. (2018). *Pedagogy of the oppressed* (50th anniversary ed.). Bloomsbury Academic.

Georgia Department of Education. (n.d.). *Science – Georgia standards of excellence*. <https://www.gadoe.org/learning/science/>

International Society for Technology in Education. (n.d.). *ISTE standards: Students*. <https://www.iste.org/standards/students>

Love, B. L. (2019). *We want to do more than survive: Abolitionist teaching and the pursuit of educational freedom*. Beacon Press.

Muhammad, G. (2023). *Unearthing joy: A guide to culturally and historically responsive teaching and learning* (Foreword by Pharrell Williams). Scholastic.

My NASA Data. (n.d.). *Earth's energy budget – lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>

NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

National Academies of Sciences, Engineering, and Medicine. (2017). *Seeing students learn science: Integrating assessment and instruction in the classroom*. National Academies Press. <https://doi.org/10.17226/23548>

National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy*.
<https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>

National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. <https://doi.org/10.17226/13165>

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press.
<https://doi.org/10.17226/18290>

TeachEngineering. (n.d.-a). *Cooking with the sun—Creating a solar oven*.
https://www.teachengineering.org/activities/view/duk_solaroven_tech_act

TeachEngineering. (n.d.-b). *Our sun and heat transfer basics: Heat it up!*.
https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

University of Colorado Boulder. (n.d.). *PhET interactive simulations: Heat & thermodynamics*.
<https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

U.S. Department of Energy. (2017). *Energy literacy: Essential principles and fundamental concepts for energy education* (Version 5.0). https://www.energy.gov/sites/prod/files/2017/07/f35/Energy_Literacy.pdf

Willard, T. (Ed.). (2014). *The NSTA quick-reference guide to the NGSS, K–12*. NSTA Press.

Day 1: Learning and Assessment Plan
Curriculum Standards GSE (Georgia Standards of Excellence) / National Curriculum Standards <u>Science - Georgia Standards of Excellence</u>
S6E4.b – <i>Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates.</i>
ISTE Technology Standard https://www.iste.org/standards/for-students
ISTE Standard 1.6.a: <i>Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.</i> This means students should select the best digital tools (e.g., Canvas, Google Slides, PhET simulations) to present their greenhouse energy models or lab reports.
Mode of Instruction Face to Face / Online Synchronous / Online Asynchronous / Hybrid
Learning Objective/ Goal (s)

Students will identify and explain the three modes of heat transfer—radiation, conduction, and convection—through observations and predictions. They will connect these processes to greenhouse efficiency and everyday experiences.

1. **Identity:** Students relate heat transfer to personal experiences such as feeling warmer in sunlight versus shade.
2. **Skills:** Students engage in scientific observation and prediction using CER.
3. **Intellect:** Students reason about energy movement through Earth’s systems.
4. **Criticality:** Students discuss equity in energy access and sustainable design.
5. **Joy:** Students explore interactive demonstrations and share creative predictions.

Science and Engineering Practices (SEPs):

- **Analyze and Interpret Data:** Students interpret observations and graphs from today’s demo.
- **Construct Explanations and Engage in Argument from Evidence:** Students use CER to explain heat transfer processes.

Crosscutting Concepts: Energy and Matter – Flows, Cycles, and Conservation

Students will define the greenhouse system under study by specifying its boundaries and modeling how energy flows through radiation, conduction, and convection. They will analyze how these processes interact to create temperature differences in soil, water, and air.

Sentence Frame (Systems & System Models):

“Define the system boundary (greenhouse model vs. ambient) and list its components.”

Disciplinary Core Idea:

Energy from the Sun drives atmospheric and surface processes. Heat transfer occurs through radiation, conduction, and convection, influencing climate, weather, and engineered systems like greenhouses.

Anchoring Phenomenon:

Why do greenhouses heat differently than the surrounding environment? Students will investigate heating rates of soil, water, and air, model energy pathways, and design solutions to optimize thermal energy transfer for sustainability.

Formative and Summative Assessment

Formative Assessment: Heating Rates Investigation

Students will compare how soil, water, and air heat up inside and outside a greenhouse. You can show your work as a lab report, video, or poster. Include a data table, a graph, and explain your results using Claim-Evidence-Reasoning (CER).

Formative Assessment: Heating Rates Investigation

Criteria	Excellent 20	Good 15	Needs Work 10	Incomplete 0
Planning & Setup	Clear steps, safe and fair test	Mostly clear steps	Some steps missing	Not clear
Data Quality	All data correct and complete	Minor mistakes	Some data missing	No data
Graph & Analysis	Graph is correct and easy to read	Graph mostly correct	Graph has mistakes	No graph
CER Explanation	Strong claim with evidence and reasoning	Claim with some reasoning	Weak reasoning	No explanation
Creativity & Tech Use	Very creative and uses tech well	Uses tech okay	Little creativity	No tech used

Students will design and test a device (like a solar oven or insulation model) to control heat transfer. Show your design with a diagram, test results, and explain how it works. You can present as a slideshow, video, or model.

Summative Assessment: Greenhouse Design Challenge

Criteria	Excellent 20	Good 15	Needs Work 10	Incomplete 0
Design & Creativity	Design is clear and very creative	Design is clear	Design needs more detail	No design
Data & Testing	Accurate data with clear results	Mostly accurate data	Some data missing	No data

Scientific Explanation	Explains heat transfer clearly	Explains most parts	Explanation is weak	No explanation
Model Accuracy	Shows energy flow correctly	Mostly correct	Some mistakes	Not shown
Presentation & Tech	Very clear and uses tech well	Clear presentation	Hard to follow	No tech used

Students will receive feedback through both digital and written formats to ensure clarity and support learning. Digital feedback will be provided on the learning platform alongside rubric scores, detailed comments, and annotations on submitted work. This allows students to see specific strengths and areas for improvement in real time. Written feedback will complement this by offering a personalized note that highlights positive achievements and provides one actionable next step for growth.

Informative feedback statements are designed to demonstrate learning and serve as an indication of mastered material. For example, comments such as *“Your graph accurately shows temperature changes and includes clear labels”* confirm that students have met key objectives. Similarly, suggestions like *“Next time, explain how convection works in your design”* guide students toward deeper understanding. These feedback practices ensure that assessments are not only evaluative but also instructional, reinforcing concepts and promoting continuous improvement.

Differentiation, Modification(s), & Accommodation(s)

This unit intentionally differentiates learning activities based on students’ varied needs, aligning with Universal Design for Learning (UDL) and the rubric’s expectation for clear, activity-oriented connections to student diversity. Three or more activities are adapted using knowledge of students’ linguistic, cognitive, and behavioral profiles.

Representation Supports:

Each lesson begins with a bilingual mini-glossary and visual concept map for key terms—radiation, conduction, convection, specific heat, and greenhouse effect—presented in English and students’ home languages. These resources include labeled diagrams and sentence frames for Claim–Evidence–Reasoning (CER), ensuring multilingual learners and students with literacy challenges access scientific vocabulary meaningfully. Captions and transcripts accompany all videos and PhET simulations to provide alternatives for auditory information, consistent with UDL checkpoints for perception and language support.

Action & Expression Options:

Students choose how to present their heating-rate investigation: a video lab report, a poster with photos and graphs, or a typed document. Oral recordings are available for students with writing difficulties, and all formats embed CER frames. For

engineering design, students may submit a slideshow, physical prototype, or narrated video. These choices reduce barriers for learners with ADHD and IEPs while maintaining rigor.

Engagement & Executive Function Supports:

To scaffold organization, lessons include visual agendas, projected timers, and color-coded material bins. Lab stations use role cards (investigator, recorder, safety lead, presenter) to clarify tasks and promote equitable participation. Students with ADHD benefit from a two-minute “stop and check” routine before data collection, paired with a brief behavior report card for on-task monitoring. Predictable routines and positive reinforcement align with evidence-based strategies for attention and behavior regulation.

Scaffolds for Data Analysis:

Pre-filled data tables and graph templates reduce cognitive load for students with executive function challenges. Advanced learners receive enriched datasets with outliers and mixed units to deepen analysis and error-checking skills. They also engage in optional variable-control mini-studies and optimization proposals, providing authentic challenge without removing core access for others.

Accessibility & Safety:

Lab spaces are decluttered, glassware is replaced with plastic, and adjustable-height workstations are provided for students with mobility needs. Safety protocols are modeled explicitly, and PPE is mandatory for heat and UV demonstrations. These universal design moves ensure physical accessibility and align with NSTA safety standards.

Behavioral & Self-Regulation Supports:

Students with severe behavior disorders have access to a designated reflection space and metacognitive prompts during labs. Predictable cool-down routines and preferential seating prevent escalation and sustain engagement. These supports are embedded universally to avoid stigmatization.

Extensions for Gifted Learners:

Honor students lead micro-investigations, mentor peers during calibration, and present expert commentaries synthesizing radiation, conduction, and convection interactions. They design optimization proposals for greenhouse efficiency, integrating quantitative reasoning and argument from evidence.

This differentiation plan ensures that all learners—multilingual students, those with ADHD or IEPs, and advanced thinkers—experience equitable access to rigorous science learning while connecting solar energy and heat transfer concepts to lived experiences and sustainability challenges.

Classroom Environment & Grouping: Desks are arranged in collaborative groups of four to promote peer learning and discourse. Seating assignments are informed by learning style and leadership quizzes, behavior records, and current academic performance to ensure balanced groups and targeted support. Students with visual impairments are positioned

near the front for optimal visibility, while those requiring individualized assistance are seated close to the instructional teacher or co-teacher for immediate support.

Accessibility & Representation Supports: English Learners and visual/auditory learners have access to video resources with closed captioning, translation options, and adjustable playback speed (e.g., Scientist Cindy’s instructional videos). Struggling readers and writers can use simplified interactive textbooks such as CK-12 Flexbook. These resources complement bilingual glossaries, visual concept maps, and captions provided during lessons, ensuring multiple means of representation.

Flexible Output & Expression: For performance-based tasks—including the heating-rate investigation and engineering design challenge—students may choose from various formats such as video lab reports, posters, oral recordings, or physical models. Similarly, for extended projects, students can propose alternative formats (e.g., acting out concepts or creating digital presentations) with teacher approval. All outputs must meet core criteria for scientific reasoning and evidence-based explanation, maintaining rigor while honoring learner variability.

Online Resources for Differentiation

- English Learners & Visual/Auditory Learners Scientist: Cindy YouTube Lesson: Watch Video (Closed captioning, translations, adjustable speed) [growth of the human population - living in balance with the environment](#) and [What is Environmental Science?](#)
- Struggling Readers & Writers: Flexbook: Access Flexbook **20.11 Solar Energy** ([Solar Energy | CK-12 Foundation](#))
- Universal Design for Learning (UDL) Guidelines CAST UDL Guidelines: Explore UDL Framework [Support multiple ways to perceive information | CAST UDL Guidelines](#)
- ELL Strategy Library Colorín Colorado: Access ELL Strategies [ELL Glossary | Colorín Colorado](#)

Introduction: 20 minutes | Standards: GSE S6E4.b, NGSS MS-PS3-3

Anchoring Phenomenon:

Why does a greenhouse heat differently than its surrounding environment?

Introduction (20 minutes):

Students will begin the lesson by watching two videos:

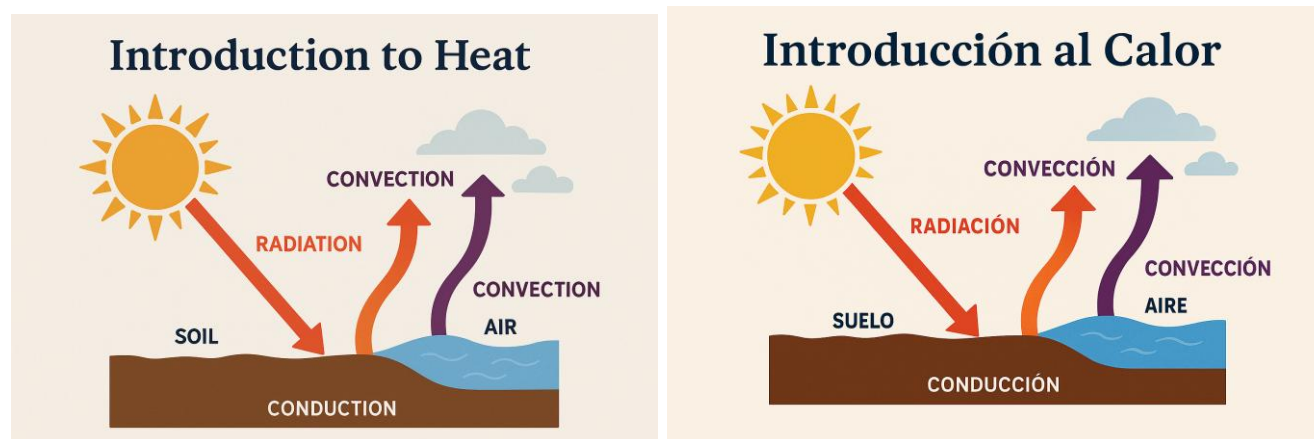
1. CK-12 Solar Power Lesson (Watch CK-12 Video)
2. YouTube Solar Cooking Demonstration (Watch Solar Cooking Video)

These videos introduce key concepts such as **radiation**, **conduction**, and **convection**, and their role in powering systems, while the second video demonstrates how solar cooking applies heat transfer principles in real-world contexts. These videos connect directly to the greenhouse unit by framing the importance of energy transfer and sustainability.

After viewing the videos, students will participate in a **Canvas discussion** (school-approved for privacy) and respond to these questions:

1. What patterns did you observe in how solar energy interacts with different surfaces and systems?
2. How do you think solar power and solar cooking relate to heat transfer in greenhouses?
3. What thoughts or emotions did you experience while watching the videos?

Students will have five minutes to submit their responses, while the teacher circulates to distribute laminated vocabulary cards for the next activity.



Vocabulary (English/Spanish):

- Radiation: Transfer of energy through electromagnetic waves (e.g., sunlight reaching Earth).
- Conduction: Heat transfer through direct contact between solids.
- Convection: Heat transfer through fluid movement (air or water).
- Solar Energy: Energy from the Sun used for heating and power.
- Greenhouse Effect: Process by which heat is trapped inside a greenhouse or Earth's atmosphere.
- Solar Cooking: Using sunlight to cook food by trapping and concentrating heat.

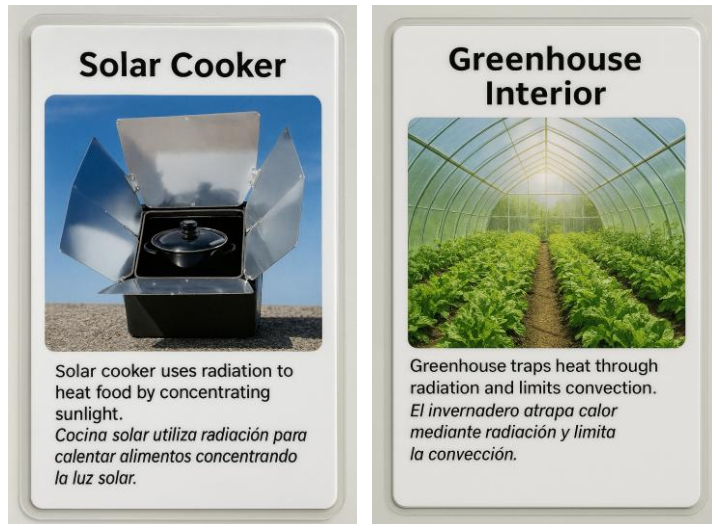
The teacher will then review selected Canvas responses and lead a discussion with follow-up questions like:

“Do you think Earth's energy flow is chaotic or structured?”

“How do radiation, conduction, and convection interact in the systems shown in the videos?”

This introduction sets the stage for deeper inquiry by engaging students in observation, reflection, and discourse about solar energy and heat transfer.

Visual Support: Display laminated cards (Solar Cooker, Greenhouse Interior, Convection Currents, Radiation Diagram, Absorption vs Reflection, Specific Heat Concept) on the front board and vocabulary station. Students will reference these cards during discussion and vocabulary review.



Learning Objectives:

- **Identity:** Connect heat transfer to personal experiences (e.g., sunlight vs shade).
- **Skills:** Observe, predict, and write CER using scientific vocabulary.
- **Intellect:** Explain how radiation, conduction, and convection interact in systems.
- **Criticality:** Discuss equity in energy access and sustainable design.
- **Joy:** Engage in interactive demos and creative predictions.

Standards: (*Georgia Department of Education, n.d., S6E4.b*); (*NGSS Lead States, 2013, MS-PS3-3*)

SEP: Analyze & Interpret Data; Construct Explanations

CCC: Energy & Matter; Systems & System Models; Cause & Effect

Formative Assessment:

Concept Check & Mini-CER (10 pts)

Students identify the dominant heat-transfer mode and write a 3-sentence CER citing demo/video.

Criteria:

- Concept identification – 2 pts
- Evidence citation – 3 pts
- Reasoning accuracy – 3 pts
- Academic vocabulary – 1 pt
- Participation – 1 pt

Process vs Product:

Process—observe, discuss, explain

Product—CER note

Alignment: S6E4.b; MS-PS3-3

Formative Assessment: Concept Check & Mini-CER (10 points)

Students identify the dominant heat-transfer mode and write a 3-sentence CER citing demo/video.

Criteria	Excellent (2 pts)	Good (1 pt)	Needs Work (0 pts)
Concept Identification	Correctly identifies dominant process	Partially correct	Incorrect or missing
Evidence Citation	Includes accurate observation/data	Vague or incomplete	No evidence
Reasoning Accuracy	Explains why using scientific principle	Limited reasoning	No reasoning
Academic Vocabulary	Uses correct terms (radiation, conduction, convection)	Uses some terms	No vocabulary

Participation	Fully engaged in discussion and CER	Partial engagement	No engagement
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Total Points: 10

Process vs Product:

Process—observe, discuss, explain

Product—CER note

Alignment: S6E4.b; MS-PS3-3

Summative Assessment: Mini-CER Explanation (10 points)

Students write a Claim-Evidence-Reasoning statement explaining which heat-transfer process was most evident during the demonstration and why.

Criteria	Excellent (2 pts)	Good (1 pt)	Needs Work (0 pts)
Claim Accuracy	Clear, correct claim	Partially correct	Incorrect or missing
Evidence Citation	Includes accurate observation/data	Vague or incomplete	No evidence
Reasoning Quality	Explains why using scientific principle	Limited reasoning	No reasoning
Vocabulary Use	Uses correct scientific terms	Uses some terms	No vocabulary
Organization & Clarity	Well-structured CER	Some structure issues	Disorganized

Total Points: 10

Process vs Product:

Process—observe, analyze, explain

Product—CER statement

Alignment: (*Georgia Department of Education, n.d., S6E4.b*); (*NGSS Lead States, 2013, MS-PS3-3*)

Exit Ticket:

- Which process (radiation/conduction/convection) was most evident today?
- Cite one observation and explain why it fits that process.

Visual Support:

Create a simple diagram in Word or PowerPoint:

- Sun → Radiation → Soil/Water/Air
- Arrows labeled “Radiation,” “Conduction,” “Convection”
- Color code: Red for radiation, Orange for conduction, Purple for convection

Body: 50 minutes

After the introduction and Canvas discussion, students transition into a hands-on activity using laminated cards. Each group of students will receive six laminated cards, each displaying an image related to solar energy and heat transfer (e.g., sunlight on soil, water heating, greenhouse interior, solar cooker, convection currents, and radiation diagram).

Six Vocabulary Terms for Day 1 Body (Different from Introduction):

1. **Absorption** – The process by which a material takes in energy (e.g., dark surfaces absorb more sunlight).
2. **Reflection** – The bouncing back of energy from a surface (e.g., light-colored surfaces reflect sunlight).
3. **Specific Heat** – The amount of heat required to change the temperature of a substance.
4. **Thermal Energy** – Energy that comes from heat; the movement of particles in matter.
5. **Albedo** – The measure of how much light or radiation is reflected by a surface.
6. **Energy Transfer** – The movement of energy from one object or system to another.

Direct Instruction (10 min):

The teacher explains the three modes of heat transfer—radiation, conduction, and convection—using clear visuals and a bilingual glossary. Students review definitions and examples while the teacher models how these processes occur in

everyday contexts (e.g., sunlight warming Earth, frying on a pan, boiling water). Explain radiation, conduction, and convection using visuals and bilingual glossary.

Scaffolding: Start with familiar examples (e.g., sunlight warming skin), then move to abstract concepts (energy transfer diagrams).

Focused Instruction (15 min):

The teacher demonstrates heating rates of soil, water, and air under a lamp (or shows a video if virtual). Students observe differences in temperature changes and discuss why materials heat at different rates. The teacher emphasizes scientific practices and safety during the demonstration.

Scaffolding: Provide a pre-filled data table template so students only need to record temperature changes, reducing cognitive load.

Guided Practice (15 min):

Students work in small groups to record observations in a data table, graph temperature changes, and identify patterns. They use laminated cards with images of energy transfer scenarios to connect observations to real-world examples. Groups collaborate to analyze data and discuss how radiation, conduction, and convection interact in greenhouse systems.

Students record observations and graph temperature changes.

Scaffolding: Provide pre-filled data tables and sentence frames for CER writing before asking students to create their own explanations. Offer sentence frames for discussion:

- “I notice ___ because ___.”
- “One pattern is ___ which means ___.”

Independent Practice (10 min):

Students write a Claim-Evidence-Reasoning (CER) statement predicting which material heats fastest and explaining why, based on their observations and scientific principles.

Before writing independently, model a CER example on the board and highlight claim, evidence, and reasoning. Body is where you detail instructional strategies, including scaffolding steps that move students from simple to complex tasks.

Closing: 20 minutes

Day 1 Closing: Introduction to Heat Transfer

Summary:

In this 20-minute closing, students consolidate their understanding of radiation, conduction, and convection introduced during the lesson. They engage with a short PhET or NASA Climate Kids simulation, share CER statements in small

groups, review key vocabulary, and complete an exit ticket via Canvas. This closing reinforces foundational concepts and sets the stage for tomorrow’s investigation comparing heating rates inside and outside a greenhouse.

Day 1 Anchoring Phenomenon

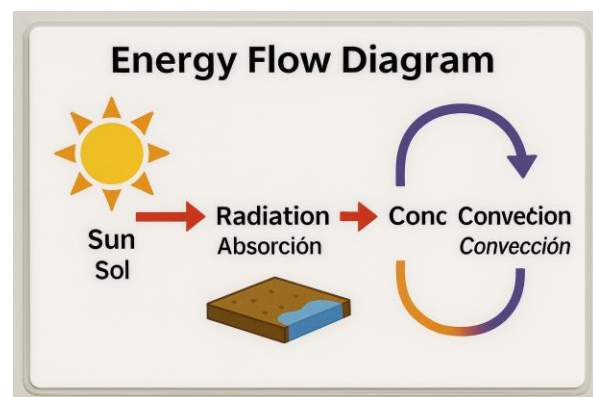
“Why does a greenhouse heat differently than the surrounding environment?”

In the Day 1 closing, students connect their initial observations and predictions about radiation, conduction, and convection to this phenomenon by explaining how these processes interact inside a greenhouse compared to the outside environment.

Timing: 20 minutes total

Steps:

1. **Transition (1–2 min):** Five minutes before the last twenty minutes of class, set a visible timer. Prompt students to finish data collection and label graphs. Materials return to the lab table; hands clear; devices ready.
2. **Synthesis & Reflection (10 min): Quick Clip (2–3 min):**
Show a short greenhouse-focused video or PhET simulation.
 - Prompts while viewing:
 - Where do you see radiation, conduction, and convection happening?
 - Identify three biotic (e.g., plants, soil microbes, insects) and three abiotic factors (e.g., sunlight, air, water) that influenced heating during today’s lab.



3. **CER Share (7–8 min):** Students read CER claims aloud in small groups and compare evidence (data tables/graphs) and reasoning (specific heat, absorption, reflection).

- Each group names one key insight about how solar energy transfers heat to soil, water, and air.
- Whole-class facilitation: connect insights into the anchoring phenomenon—
“Why do greenhouses heat differently than the surrounding environment?”

CCC Focus: Energy & Matter; Systems & System Models; Cause & Effect

Return to Anchor:

“How did today’s findings explain why greenhouses heat differently than the surrounding environment?”

SEP Self-Check (2 minutes):

Which SEP did you use today? (Analyze & Interpret Data) What artifact shows your proficiency? (e.g., graph, CER statement)

CCC Writing Prompt:

Write two sentences: (a) Define the boundary of our system (Systems & System Models), (b) Explain what caused faster heating (Cause & Effect).

CCC Discussion Prompt:

Turn to your partner and discuss:




“How does energy flow through radiation, conduction, and convection in today’s demo? (Energy & Matter) What system components influenced heating patterns?”

4. **Vocabulary Review (5 min):** Terms: absorption, reflection, specific heat, thermal energy, albedo, energy transfer
 Activity:

- Match each term to its definition (Canvas Question Bank or Adobe Express card sort).
- Use one term in a sentence about today’s investigation (e.g., “Water showed a slower temperature rise due to its specific heat.”).

Tip: Post a bilingual mini-glossary slide for multilingual learners; allow text or short audio replies.

Summary Chart

Process	Definition	Example
Radiation Radiación	Transfer of heat through electromagnetic waves. <i>Transferencia de calor mediante ondas electromagnéticas.</i>	 Sunlight warming soil
Conduction Conducción	Transfer of heat through direct contact. <i>Transferencia de calor mediante contacto directo.</i>	 Pot on a stove <i>Olla en una estufa</i>
Convection Convección	Transfer of heat through moving fluid. <i>Transferencia de calor mediante fluido en movimiento.</i>	 Warm air rising <i>Aire caliente ascendiendo</i>

5. **Exit Ticket (5 min):** Submit via Canvas or Adobe Express:

- Which heat transfer process was most evident in today’s demonstration? (Choose one: radiation, conduction, convection) + 1–2 sentences citing data.
 - How might a solar cooker use the same principles? (Name at least two principles—e.g., radiation absorption, reflective concentration, insulation to limit convection—and connect to expected temperature change.)
- Accessibility: Offer paper or audio submission for students who need it.

SEP Self-Check (2 minutes):

Which Science and Engineering Practice did you use today? (e.g., Analyze Data, Develop Models, Argue from Evidence).
What artifact shows your proficiency? (graph, CER, model, prototype).

CCC Writing & Discussion Prompts:

- *Energy & Matter:* “Explain how energy flows through radiation, conduction, and convection in today’s investigation.”
- *Systems & System Models:* “Define the boundaries of our greenhouse system and list its components.”

- *Cause & Effect:* “What caused the differences in heating rates among soil, water, and air?”

Next Steps (Teacher Note)

Students finish CER-based lab report by next class.

Feedback will focus on investigation quality, graph accuracy, and reasoning.

Preview next lesson: Data Analysis & Energy Pathways Modeling—students will build models showing radiation → absorption → conduction → convection interactions inside the greenhouse and compare with outside conditions.

Introduce engineering design challenge (solar oven/insulation prototype) for later application.

DCI (Disciplinary Core Idea)

Energy from the Sun drives atmospheric and surface processes. Heat transfer occurs through radiation, conduction, and convection, influencing climate, weather, and engineered systems like greenhouses.

SEP (Science and Engineering Practices)

- **Analyze and Interpret Data:** Students interpret observations and graphs from today’s demo.
- **Construct Explanations and Engage in Argument from Evidence:** Students use CER to explain heat transfer processes.

CCC (Crosscutting Concepts)

- **Energy and Matter:** Trace energy flow through radiation, conduction, and convection.
- **Systems and System Models:** Identify components and boundaries of the greenhouse system.
- **Cause and Effect:** Explain why certain materials heat faster than others.

Materials, Tech & Safety

Classroom Setup & Materials

- A dedicated materials table is organized with all necessary items for the lesson (handouts, worksheets, notebook paper, laminated cards, thermometers, soil/water containers, and safety goggles).
- All digital resources (instructions, videos, vocabulary slides, and exit ticket links) are uploaded to Canvas for easy access.
- Desks are arranged in groups of four to promote cooperative learning. Groups are assigned based on students’ learning style quiz, leadership style quiz, behavior record, and current grade to ensure balanced collaboration.

Behavior Management

- A bell system is used for individual misbehavior:
 - Green Bell: First warning—student relocates to a different seat.
 - Yellow Bell: Second warning—student moves to an isolated desk.
 - Red Bell: Third warning—student is sent to the administrator.
- For whole-class disruptions, the teacher will flicker the lights as a signal for students to return to seats and quiet down.
- Classroom norms are posted on a whiteboard charter and reinforced daily. Positive behavior is rewarded with bonus points or small incentives.

Instructional Support

- Currently, the primary teacher provides all support:
 - Circulate during work periods to monitor progress, answer questions, and ensure safety compliance.
 - Offer one-on-one assistance for students who are disengaged or need clarification.
- A visual timer is projected to manage transitions between activities, helping students stay on task.
- If a co-teacher is added later, they will assist with:
 - Pulling students for individualized instruction.
 - Providing targeted support for students with IEPs or language needs.
 - Helping manage behavior and facilitate small-group work.

Safety Protocols

- For lessons involving lab experiments or demonstrations, students must follow NSTA safety guidelines signed by students and guardians during the first week of school.
- Personal Protective Equipment (PPE): Safety goggles and gloves are required when handling heat sources or soil/water samples.
- Heat lamps and electrical cords are monitored to prevent burns or tripping hazards.
- Students are reminded of no horseplay and proper handling of materials before starting any activity.
- Emergency procedures (fire extinguisher location, evacuation routes) are reviewed at the start of lab-based lessons.

Accessibility & Equity

- Provide adjustable-height workstations for students with mobility needs.
- Offer paper or audio alternatives for exit tickets and CER tasks for students with IEPs or literacy challenges.
- Ensure bilingual glossaries and captions for videos to support multilingual learners.

Layered Texts and Other Materials

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

CK-12 Foundation. (n.d.). *Solar energy (20.11)—CK-12 Earth science for middle school*. <https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/20.11/primary/lesson/solar-power-ms-es/>

Colorín Colorado. (n.d.). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>

International Society for Technology in Education. (n.d.). *ISTE standards: Students*. <https://www.iste.org/standards/students>

My NASA Data. (n.d.). *Earth's energy budget—Lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>

NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy*. <https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>

TeachEngineering. (n.d.-a). *Cooking with the sun—Creating a solar oven*. https://www.teachengineering.org/activities/view/duk_solaroven_tech_act

TeachEngineering. (n.d.-b). *Our sun and heat transfer basics: Heat it up!*. https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

United States Botanic Garden, National Center for Appropriate Technology, & City Blossoms. (2019). *Greenhouse manual: An introductory guide for educators*. <https://www.usbg.gov/greenhouse-manual>

University of Colorado Boulder. (n.d.). *PhET interactive simulations: Heat & thermodynamics*. <https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

References

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

CK-12 Foundation. (n.d.). *Biology flexbook*. <https://flexbooks.ck12.org>

Colorín Colorado. (n.d.). *ELL classroom strategy library*. <https://www.colorincolorado.org>

Georgia Department of Education. (n.d.). *Georgia standards of excellence: Science*. <https://case.georgiastandards.org/27a08dc6-416e-11e7-ba71-02bd89fdd987/27a08dc6-416e-11e7-ba71-02bd89fdd987>

International Society for Technology in Education. (n.d.). *ISTE standards for students*. <https://www.iste.org/standards/for-students>

My NASA Data. (n.d.). *Earth's energy budget lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>

NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy*. <https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>

National Renewable Energy Laboratory. (n.d.). *Education resources for students*. <https://www.nrel.gov/about/education-students-resources>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*. <https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

Science Buddies. (n.d.). *Investigate the greenhouse effect*. https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvSci_p047/environmental-science/what-is-the-greenhouse-effect

Scientist Cindy. (n.d.-a). *Growth of the human population – living in balance with the environment* [Video]. YouTube. <https://www.youtube.com/watch?v=SQXD2cILnO0>

Scientist Cindy. (n.d.-b). *What is environmental science?* [Video]. YouTube. <https://www.youtube.com/watch?v=53ptdg3tqqY>

TeachEngineering. (n.d.). *Our sun and heat transfer basics*. https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

United States Botanic Garden. (n.d.). *Greenhouse manual*. <https://www.usbg.gov/greenhouse-manual>

Day 2: Learning and Assessment Plan

Curriculum Standards GSE (Georgia Standards of Excellence) / National Curriculum Standards **Science - Georgia Standards of Excellence**

S6E4.b – *Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates.*

ISTE Technology Standard

<https://www.iste.org/standards/for-students>

ISTE 1.1.c emphasizes seeking feedback through technology and demonstrating learning in varied ways. This is more aligned with the instructional design for Day 2 because students will:

- Upload CER statements or lab reports to Canvas for teacher feedback.
- Use PhET simulations for conceptual understanding.
- Submit work in multiple formats (video, poster, oral recording), which matches UDL principles.

The change reflects a pedagogical upgrade: Instead of just 'pick a tool,' students now use technology to improve their practice and show learning in diverse ways.

Mode of Instruction Face to Face / Online Synchronous / Online Asynchronous / Hybrid

Learning Objective / Goal (s)

Students will:

- **Identity:** Connect heat transfer to personal and cultural experiences by discussing real-world examples (e.g., why cars heat up in sunlight, cooking traditions, home heating practices).
Prompt: “How does understanding heat transfer help communities design sustainable food systems?”
- **Skills:** Plan and conduct a controlled investigation comparing heating rates of soil, water, and air inside and outside a greenhouse; collect and record temperature data at regular intervals; organize data in tables and graphs; write CER explanations.
Prompt: “What steps did you take to ensure your test was fair?”
- **Intellect:** Analyze patterns of heat absorption and transfer among different materials and explain findings using scientific principles of radiation, conduction, convection, and specific heat capacity.
Prompt: “Why do oceans stay cooler than land even though both receive sunlight?”
- **Criticality:** Reflect on equity in access to energy-efficient technologies and sustainable agriculture.
Prompt: “Who benefits most from greenhouse technology? Who might be left out?”
- **Joy:** Engage in hands-on experiments, collaborative data analysis, and creative graphing activities.
Prompt: “What part of today’s investigation was most exciting for you?”

Science and Engineering Practices (SEPs):

- **Plan and Carry Out Investigations:** Students design and conduct a controlled experiment comparing heating rates.
- **Analyze and Interpret Data:** Students collect temperature readings, create graphs, and identify patterns.
- **Construct Explanations and Engage in Argument from Evidence:** Students use CER to explain why different materials heat at different rates.

Anchoring Phenomenon:

Why does a greenhouse heat differently than the surrounding environment?

Students will investigate heating rates of soil, water, and air, model energy pathways, and connect findings to real-world greenhouse efficiency and sustainability.

Sentence Frame (Cause & Effect): Explain why water warms slower (specific heat) using claim-evidence-reasoning.

Formative and Summative Assessment

Formative Assessment (in-class) — Heating Rates Investigation Check (20 pts)

When: During the Body of Day 2 (as students collect data and draft graphs).

Artifacts: Data table, rate calculations, graph, mini-CER (3–4 sentences).

Criteria & Descriptors (4 × 5 pts = 20)

Heating Rates Investigation Check (20 pts)

Criterion (5 pts each)	Exceeds (5)	Meets (4)	Approaching (2–3)	Needs (0–1)
Fair Test & Safety	Variables/controls clearly stated; mass checked; identical containers; calibration done; PPE on	Mostly fair; minor control lapse; PPE on	Some controls missing; inconsistent setup	Unsafe OR not set up
Data Quality	Complete table with time stamps; at least 2–3 trials; notes outliers	Minor gaps (one trial or a few missing points)	Multiple missing points; unclear intervals	No usable data
Graph & Rate	Correct axes + units; clear legend; computed slope (°C/min) for at least 2 media	Graph correct; rate for at least 1 medium	Axis/units errors; no rate	No graph
Mini-CER	Claim names fastest heating + numeric evidence (ΔT , slope) + mechanism (specific heat/absorption/convection)	Claim + evidence present; reasoning partial	Vague claim or missing mechanism	Missing CER

Teacher feedback stems (quick & actionable)

- *Axes:* “Add °C to y-axis and minutes to x-axis.”
- *Rate:* “Compute slope for soil and water; circle the steepest.”
- *Mechanism:* “Link your claim to specific heat (water > soil) and absorption.”

Bilingual mini-CER frames

- Claim / Afirmación: “I claim that ___ heated fastest because ___.” / “Afirmo que ___ calentó más rápido porque ___.”
- Evidence / Evidencia: “Our data show $\Delta T = \text{___}^\circ\text{C}$ in ___ min; slope = $\text{___}^\circ\text{C}/\text{min}$.” / “Nuestros datos muestran $\Delta T = \text{___}^\circ\text{C}$ en ___ min; pendiente = $\text{___}^\circ\text{C}/\text{min}$.”
- Reasoning / Razonamiento: “Water’s higher specific heat explains slower warming.” / “El calor específico mayor del agua explica su calentamiento más lento.”

2) Summative Assessment (after class) — Investigation Report (30 pts)

When: Due next class (start of Day 3).

Artifacts: Full report (can be poster/slide/video/typed), includes procedure, table, rates, graph, CER, reflection.

Rubric (6 × 5 pts = 30)

Investigation Report (30 pts)

Criterion (5 pts each)	Exceeds (5)	Meets (4)	Approaching (2–3)	Needs (0–1)
Question & Fair Test	Clear investigable question; precise variables/controls; mass/containers equal; calibration noted	Question clear; controls mostly consistent	Partial question; unclear controls	Missing/incorrect
Procedure & Safety	Step-wise, reproducible; PPE and heat safety documented	Procedure mostly clear; safety noted	Vague steps; safety generic	Unsafe or missing
Data & Rates	Complete table; multi-trial averages; rate ($^\circ\text{C}/\text{min}$) per medium; outlier note	Table complete; rates for most media	Partial table; no rates OR incorrect units	Missing data
Graph Quality	Axes with units; readable; legend/colors; highlights steepest slope	Mostly correct; minor label issues	Scale/label errors; hard to read	Missing graph
CER Explanation	Claim + numeric evidence; mechanism includes specific heat / absorption / convection; connects to phenomenon	Claim + evidence; mechanism partial	Vague claim; limited evidence	Missing CER

Reflection & Limits	Notes measurement limits (e.g., lamp distance, ambient airflow); proposes 1 improvement	Mentions one limitation	Vague or generic	Missing
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Student directions (clear & brief)

- Title + Question; 2) Fair test diagram (mass, containers, exposure);
- 3) Data table + rates;
- 4) Graph;
- 5) CER;
- 6) Reflection (1–2 limitations + 1 improvement).

Accessibility/UDL options

- Typed/slide/video/poster accepted.
- Oral explanation (captioned) allowed; all must include CER + numbers.

Differentiation, Modification(s), & Accommodation(s)

This unit intentionally differentiates learning activities based on students’ varied needs, aligning with Universal Design for Learning (UDL) and the rubric’s expectation for clear, activity-oriented connections to student diversity. Three or more activities are adapted using knowledge of students’ linguistic, cognitive, and behavioral profiles.

Representation Supports:

Each lesson begins with a bilingual mini-glossary and visual concept map for key terms—radiation, conduction, convection, specific heat, and greenhouse effect—presented in English and students’ home languages. These resources include labeled diagrams and sentence frames for Claim–Evidence–Reasoning (CER), ensuring multilingual learners and students with literacy challenges access scientific vocabulary meaningfully. Captions and transcripts accompany all videos and PhET simulations to provide alternatives for auditory information, consistent with UDL checkpoints for perception and language support.

Action & Expression Options:

Students choose how to present their heating-rate investigation: a video lab report, a poster with photos and graphs, or a typed document. Oral recordings are available for students with writing difficulties, and all formats embed CER frames. For engineering design, students may submit a slideshow, physical prototype, or narrated video. These choices reduce barriers for learners with ADHD and IEPs while maintaining rigor.

Engagement & Executive Function Supports:

To scaffold organization, lessons include visual agendas, projected timers, and color-coded material bins. Lab stations use role cards (investigator, recorder, safety lead, presenter) to clarify tasks and promote equitable participation. Students with ADHD benefit from a two-minute “stop and check” routine before data collection, paired with a brief behavior report card for on-task monitoring. Predictable routines and positive reinforcement align with evidence-based strategies for attention and behavior regulation.

Scaffolds for Data Analysis:

Pre-filled data tables and graph templates reduce cognitive load for students with executive function challenges. Advanced learners receive enriched datasets with outliers and mixed units to deepen analysis and error-checking skills. They also engage in optional variable-control mini-studies and optimization proposals, providing authentic challenge without removing core access for others.

Accessibility & Safety:

Lab spaces are decluttered, glassware is replaced with plastic, and adjustable-height workstations are provided for students with mobility needs. Safety protocols are modeled explicitly, and PPE is mandatory for heat and UV demonstrations. These universal design moves ensure physical accessibility and align with NSTA safety standards.

Behavioral & Self-Regulation Supports:

Students with severe behavior disorders have access to a designated reflection space and metacognitive prompts during labs. Predictable cool-down routines and preferential seating prevent escalation and sustain engagement. These supports are embedded universally to avoid stigmatization.

Extensions for Gifted Learners:

Honor students lead micro-investigations, mentor peers during calibration, and present expert commentaries synthesizing radiation, conduction, and convection interactions. They design optimization proposals for greenhouse efficiency, integrating quantitative reasoning and argument from evidence.

This differentiation plan ensures that all learners—multilingual students, those with ADHD or IEPs, and advanced thinkers—experience equitable access to rigorous science learning while connecting solar energy and heat transfer concepts to lived experiences and sustainability challenges.

Classroom Environment & Grouping: Desks are arranged in collaborative groups of four to promote peer learning and discourse. Seating assignments are informed by learning style and leadership quizzes, behavior records, and current academic performance to ensure balanced groups and targeted support. Students with visual impairments are positioned near the front for optimal visibility, while those requiring individualized assistance are seated close to the instructional teacher or co-teacher for immediate support.

Accessibility & Representation Supports: English Learners and visual/auditory learners have access to video resources with closed captioning, translation options, and adjustable playback speed (e.g., Scientist Cindy’s instructional videos). Struggling readers and writers can use simplified interactive textbooks such as CK-12 Flexbook. These resources complement bilingual glossaries, visual concept maps, and captions provided during lessons, ensuring multiple means of representation.

Flexible Output & Expression: For performance-based tasks—including the heating-rate investigation and engineering design challenge—students may choose from various formats such as video lab reports, posters, oral recordings, or physical models. Similarly, for extended projects, students can propose alternative formats (e.g., acting out concepts or creating digital presentations) with teacher approval. All outputs must meet core criteria for scientific reasoning and evidence-based explanation, maintaining rigor while honoring learner variability.

Online Resources for Differentiation

- English Learners & Visual/Auditory Learners Scientist: Cindy YouTube Lesson: Watch Video (Closed captioning, translations, adjustable speed) [growth of the human population - living in balance with the environment](#) and [What is Environmental Science?](#)
- Struggling Readers & Writers: Flexbook: Access Flexbook **20.11 Solar Energy** ([Solar Energy | CK-12 Foundation](#))
- Universal Design for Learning (UDL) Guidelines CAST UDL Guidelines: Explore UDL Framework [Support multiple ways to perceive information | CAST UDL Guidelines](#)

ELL Strategy Library Colorín Colorado: Access ELL Strategies [ELL Glossary](#) | [Colorín Colorado](#)

Introduction: 20 minutes | Standards: GSE S6E4.b, NGSS MS-PS3-3

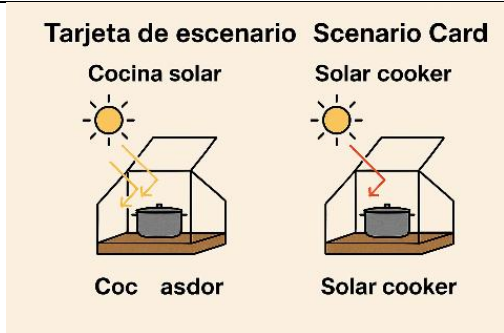
Standards: GSE S6E4.b; NGSS MS-PS3-3

Anchoring Phenomenon: *Why does a greenhouse heat differently than the surrounding environment?*

Purpose: Today’s introduction activates curiosity and sets the stage for a hands-on investigation comparing heating rates inside and outside a greenhouse. Students will predict outcomes, connect to prior knowledge, and prepare for data collection.

Warm-Up (5 minutes)

- **Quick Review:**



Project the card to anchor the idea that **radiation enters**, **absorption happens**, and **airflow matters**—all of which they’ll later connect to the greenhouse investigation.

Prompt (English/Spanish):

- *Where do you see radiation/conduction/convection happening?*
- *¿Dónde ves radiación/conducción/convección?*

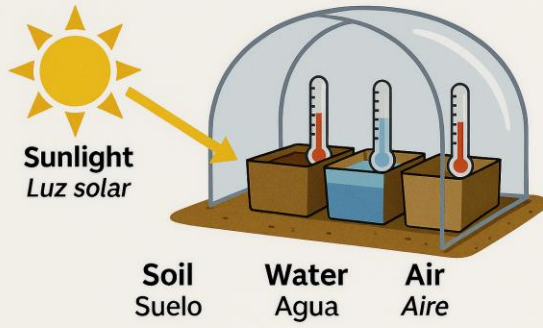
Teacher move: Invite one quick pair-share; capture 2–3 student ideas to the board as “hypotheses” they will test with data.

- *Ask: “Yesterday, we explored radiation, conduction, and convection. Which process do you think will dominate inside a greenhouse?”*
- Display yesterday’s vocabulary wall and invite students to share one observation from Day 1.

Engage with Phenomenon (10 minutes)

- Show a **NASA Climate Kids clip** or PhET simulation illustrating greenhouse heating.

Mini-Greenhouse Setup



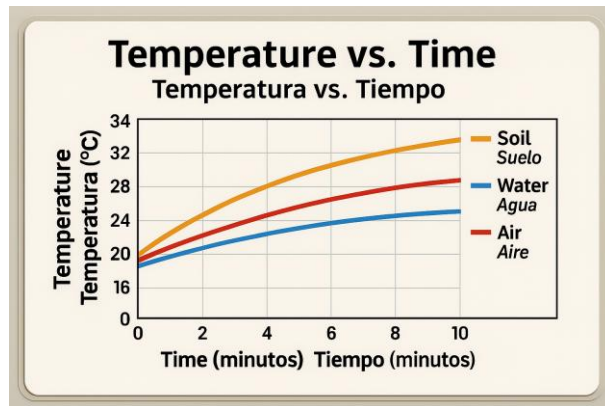
- **Prompts while viewing:**
 - *Where do you see radiation, conduction, and convection happening?*
 - *Why might soil heat faster than water?*
- Scaffold with bilingual mini-glossary (English/Spanish):
 - **Radiation / Radiación**
 - **Conduction / Conducción**
 - **Convection / Convección**
 - **Specific Heat / Calor específico**
 - **Absorption / Absorción**
 - **Reflection / Reflexión**

Prediction & Discussion (5 minutes)

- Students respond in **Canvas** to these questions:
 1. Which material (soil, water, air) will heat fastest inside the greenhouse? Why?
 2. How might this investigation help communities design sustainable food systems?
- Teacher circulates, distributing laminated scenario cards (Radiation, Absorption vs. Reflection, Conduction, Convection) for use in the body of the lesson.

Transition:

Students will set up mini-greenhouses and begin recording initial temperatures.



- Gallery walk: groups post graphs and use sentence frames:

“I notice ___ because ___.”

“One pattern is ___ which means ___.”

- **Independent Practice (10 min):**

- Write a CER explaining which material heated fastest and why.

- Sentence frames:

- **Claim:** I claim that ___ because ___.

- **Evidence:** My data shows ___ increased by ___°C in ___ minutes.

- **Reasoning:** This happens because ___ has a higher/lower specific heat capacity than ___.

Exit Ticket (Canvas or paper/audio alternative)

EXIT TICKET

DAY 2 – HEATING RATES INVESTIGATION

Complete the following questions before leaving class.

HEAT TRANSFER PROCESS

Which heat transfer process was most evident in today's investigation?

Radiation Conduction Convection

Explain your choice in 1–2 sentences using evidence from your data.

SPECIFIC HEAT

Why did water heat more slowly than soil?

Include the term *specific heat* in your explanation.

REAL-WORLD CONNECTION

How might a solar cooker use the same principles you observed today?

Mention at least two principles (e.g. radiation absorption, insulation to reduce convection, reflective surfaces)

OPTIONAL UPLOAD

Attach a photo of your graph or data table.

- Which heat transfer process was most evident today? Cite one data point.
- How might a solar cooker use the same principles?

Closing: 20 minutes

Day 2 Closing: Greenhouse Heating Investigation

Summary:

Students synthesize observations from the greenhouse heating investigation through a short PhET simulation, collaborative CER sharing, and a quick vocabulary review. The session ends with an exit ticket submitted via Canvas, reinforcing key concepts of radiation, conduction, and convection while previewing the next lesson on data analysis and modeling.

Connection to Day 1:

Yesterday's closing introduced the anchoring phenomenon and helped students identify radiation, conduction, and convection through predictions and observations. Today builds on that foundation by applying these concepts in a real investigation and connecting them to system boundaries and energy flow.

Day 2 Anchoring Phenomenon

“Why does a greenhouse heat differently than the surrounding environment?”

In the Day 2 closing, students connect their controlled investigation of heating rates inside and outside a greenhouse to this phenomenon by explaining how radiation, conduction, and convection interact within the greenhouse system compared to the ambient environment.

Timing: 20 minutes total

Steps:

1. **Transition (1 min):** Signal end of data collection; students organize materials and prepare for reflection.
2. **Synthesis & Reflection (6 min):** Show PhET simulation on heat transfer in greenhouses.
 - Prompts:
 - Where do you see radiation, conduction, and convection happening?

Pattern Chart

Soil heats fastest → Air heats moderately → Water heats slowest. *El suelo calienta más rápido El aire calienta moderadamente → El agua calienta más*

Sentence Frames

Claim: Afirmación:	_____
Evidence: Evidencia:	_____
Razonamiento:	_____

- Identify three biotic and three abiotic factors that influenced heating today.
3. **CER Share (5 min):** Students share Claim–Evidence–Reasoning statements in small groups. Each group identifies one insight about how solar energy transfers heat to soil, water, and air. Teacher connects insights into the anchoring phenomenon: *Why do greenhouses heat differently than the surrounding environment?*

CCC Focus: Energy & Matter; Systems & System Models; Cause & Effect

Return to Anchor:

How did today's data analysis and modeling help explain why a greenhouse heats differently than its surroundings? Write one sentence connecting your CER claim or model to this question

SEP Self-Check (2 minutes):

Which SEP did you use today? (Plan and Carry Out Investigations) What artifact shows your proficiency? (e.g., data table, graph, CER statement)

CCC Writing Prompt: (Canvas or Notebook)

Write two sentences:

- (a) *Define the boundary of our system (Systems & System Models).*
- (b) *Explain what caused faster heating (Cause & Effect).*

CCC Discussion Prompt (Think-Pair-Share)

Turn to your partner and discuss:

- How did energy flow through radiation, conduction, and convection in today's investigation? (Energy & Matter)
- What system components influenced heating patterns? (Systems & System Models)
- Why did soil heat faster than water? (Cause & Effect)

- 4. **Vocabulary Quick Review (4 min):** Match-and-explain activity for terms: absorption, reflection, specific heat, thermal energy, albedo, energy transfer. Students use one term in a sentence about today's investigation.
- 5. **Exit Ticket (4 min):**
 - Which heat transfer process was most evident today? Cite data.
 - How might a solar cooker use the same principles?Submission via Canvas or paper/audio alternative for accessibility.

SEP Self-Check (2 minutes):

Which Science and Engineering Practice did you use today? (e.g., Analyze Data, Develop Models, Argue from Evidence). What artifact shows your proficiency? (graph, CER, model, prototype).

CCC Writing & Discussion Prompts:

- *Energy & Matter*: “Explain how energy flows through radiation, conduction, and convection in today’s investigation.”
- *Systems & System Models*: “Define the boundaries of our greenhouse system and list its components.”
- *Cause & Effect*: “What caused the differences in heating rates among soil, water, and air?”

Preview Next Lesson: Analyze graphs and build energy pathway models.

Additional CCC Writing Prompts (Systems & Cause & Effect):

Write two sentences:

- Define the boundary of our system (Systems & System Models).
- Explain what caused faster heating (Cause & Effect).

DCI (Disciplinary Core Idea)

Energy from the Sun drives atmospheric and surface processes. Heat transfer occurs through radiation, conduction, and convection, influencing climate, weather, and engineered systems like greenhouses.

SEP (Science and Engineering Practices)

- **Plan and Carry Out Investigations:** Students designed and conducted a controlled experiment comparing heating rates of soil, water, and air inside and outside a greenhouse.
- **Analyze and Interpret Data:** Students collected temperature readings, created graphs, and identified patterns.
- **Construct Explanations and Engage in Argument from Evidence:** Students used CER to explain why different materials heat at different rates.

CCC (Crosscutting Concepts)

- **Energy and Matter:** Analyze how energy flows through radiation, conduction, and convection in a greenhouse system.
- **Systems and System Models:** Define greenhouse system boundaries and components.
- **Cause and Effect:** Explain why water heats slower than soil using specific heating principles.

Materials, Tech & Safety

Classroom Setup & Materials

- A dedicated materials table is organized with all necessary items for the lesson (handouts, worksheets, notebook paper, laminated cards, thermometers, soil/water containers, and safety goggles).
- All digital resources (instructions, videos, vocabulary slides, and exit ticket links) are uploaded to Canvas for easy access.
- Desks are arranged in groups of four to promote cooperative learning. Groups are assigned based on students' learning style quiz, leadership style quiz, behavior record, and current grade to ensure balanced collaboration.

Behavior Management

- A bell system is used for individual misbehavior:
 - Green Bell: First warning—student relocates to a different seat.
 - Yellow Bell: Second warning—student moves to an isolated desk.
 - Red Bell: Third warning—student is sent to the administrator.
- For whole-class disruptions, the teacher will flicker the lights as a signal for students to return to seats and quiet down.
- Classroom norms are posted on a whiteboard charter and reinforced daily. Positive behavior is rewarded with bonus points or small incentives.

Instructional Support

- Currently, the primary teacher provides all support:
 - Circulate during work periods to monitor progress, answer questions, and ensure safety compliance.
 - Offer one-on-one assistance for students who are disengaged or need clarification.
- A visual timer is projected to manage transitions between activities, helping students stay on task.
- If a co-teacher is added later, they will assist with:
 - Pulling students for individualized instruction.
 - Providing targeted support for students with IEPs or language needs.
 - Helping manage behavior and facilitate small-group work.

Safety Protocols

- For lessons involving lab experiments or demonstrations, students must follow NSTA safety guidelines signed by students and guardians during the first week of school.
- Personal Protective Equipment (PPE): Safety goggles and gloves are required when handling heat sources or soil/water samples.
- Heat lamps and electrical cords are monitored to prevent burns or tripping hazards.
- Students are reminded of no horseplay and proper handling of materials before starting any activity.
- Emergency procedures (fire extinguisher location, evacuation routes) are reviewed at the start of lab-based lessons.

Accessibility & Equity

- Provide adjustable-height workstations for students with mobility needs.
- Offer paper or audio alternatives for exit tickets and CER tasks for students with IEPs or literacy challenges.
- Ensure bilingual glossaries and captions for videos to support multilingual learners.

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Bilingual Mini Glossary. (n.d.). Key terms in English and Spanish. [Unpublished educational material].

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<https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/20.11/primary/lesson/solar-power-ms-es/>

Canvas. (n.d.). *Canvas quiz.* <https://www.instructure.com/canvas>

Energy Transfer Cards. (n.d.). Laminated cards illustrating radiation, conduction, and convection scenarios. [Unpublished educational material].

My NASA Data. (n.d.). *Earth's energy budget—Lesson plans.* <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>

NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations.*

<https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

References

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Colorín Colorado. (n.d.). *ELL classroom strategy library.* <https://www.colorincolorado.org>

Georgia Department of Education. (n.d.). *Georgia standards of excellence: Science.*

<https://case.georgiastandards.org/27a08dc6-416e-11e7-ba71-02bd89fdd987/27a08dc6-416e-11e7-ba71-02bd89fdd987>

International Society for Technology in Education. (n.d.). *ISTE standards for students.*

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NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy.* <https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>

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Scientist Cindy. (n.d.-a). *Growth of the human population – living in balance with the environment* [Video]. YouTube. <https://www.youtube.com/watch?v=SQXD2cILnO0>

Scientist Cindy. (n.d.-b). *What is environmental science?* [Video]. YouTube. <https://www.youtube.com/watch?v=53ptdg3tqqY>

TeachEngineering. (n.d.). *Our sun and heat transfer basics.* https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

United States Botanic Garden. (n.d.). *Greenhouse manual.* <https://www.usbg.gov/greenhouse-manual>

Day 3: Learning and Assessment Plan

Curriculum Standards GSE (Georgia Standards of Excellence) / National Curriculum Standards [Science - Georgia Standards of Excellence](#)

S6E4.b – *Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates.*

ISTE Technology Standard

<https://www.iste.org/standards/for-students>

ISTE 1.1.c emphasizes seeking feedback through technology and demonstrating learning in varied ways. This is more aligned with the instructional design for Day 2 because students will:
 - Upload CER statements or lab reports to Canvas for teacher feedback.

- Use PhET simulations for conceptual understanding.
- Submit work in multiple formats (video, poster, oral recording), which matches UDL principles.

Mode of Instruction Face to Face / Online Synchronous / Online Asynchronous / Hybrid

Learning Objective/Goals

Day 3 Learning Objectives: Data Analysis & Energy Pathways Modeling

Students will:

- **Identity:** Connect heat transfer concepts to personal and cultural experiences by discussing how energy transfer affects daily life (e.g., home heating, cooking, greenhouse food systems).
Prompt: “How does understanding energy pathways help communities design sustainable solutions?”
- **Skills:** Analyze and interpret temperature data from the greenhouse investigation; create graphs; develop and use models to represent energy flow; write CER explanations.
Prompt: “What steps did you take to ensure your graph accurately represents the data?”
- **Intellect:** Reason about why soil, water, and air heat differently using scientific principles of radiation, conduction, convection, and specific heat capacity.
Prompt: “Why do oceans stay cooler than land even though both receive sunlight?”
- **Criticality:** Discuss equity in access to energy-efficient technologies and sustainable agriculture.
Prompt: “Who benefits most from greenhouse technology? Who might be left out?”
- **Joy:** Engage in collaborative modeling and creative representation of energy pathways.
Prompt: “What part of today’s modeling activity was most exciting for you?”

Science and Engineering Practices (SEPs):

- **Analyze and Interpret Data:** Students interpret graphs and patterns from the greenhouse investigation.
- **Develop and Use Models:** Students construct energy pathway models showing interactions among radiation, conduction, and convection.
- **Construct Explanations and Engage in Argument from Evidence:** Students justify claims using CER and connect findings to scientific principles.

Anchoring Phenomenon:

“Why does a greenhouse heat differently than the surrounding environment?”

Students will connect their data analysis and energy pathway models to this phenomenon by illustrating how radiation, absorption, conduction, and convection combine to create temperature differences inside the greenhouse.

Sentence Frame (Patterns & Scale/Proportion): Describe the pattern in graphs; comment on slope differences and what they mean.

Formative and Summative Assessment

Formative: Analyze investigation data, create graphs, CER writing, peer feedback during model construction. Summative: Energy Pathways Model (digital or physical) with justification connecting model to class data.

Formative Assessment

Criteria	Excellent 20	Good 15	Needs Work 10	Incomplete 0
Data Analysis Accuracy	All data accurate; graphs labeled	Minor errors	Multiple errors	Not attempted
CER Writing	Claim, evidence, reasoning fully aligned	Missing minor details	Unclear or incomplete	Not submitted
Participation & Peer Feedback	Fully engaged	Partial engagement	Minimal engagement	Absent

Summative Assessment

Criteria	Excellent 30	Good 24	Needs Work 18	Incomplete 0
Scientific Accuracy	All processes shown accurately	Minor inaccuracies	Major gaps	Not attempted
Visual Clarity	Neat, labeled, easy to interpret	Some labels missing	Disorganized	Not submitted
Justification	Connects model to data using CER	Partial connection	Weak reasoning	No justification

Delivery note for all days: *I will provide handwritten feedback with your score and specific comments. Please use my feedback to revise and resubmit for a regrade. If you need extra practice, check the Layered Text and Other Material section (videos, readings, simulations).*

Informal formative assessments (discussion, closing) are not graded; I use them to monitor your progress and plan supports.

Formative (Graphs + CER + Peer Feedback)

- Excellent (Score: 18–20/20):
“Your graph is correctly scaled and labeled (time on x-axis, °C on y-axis) and shows clear trends. Your CER states a precise claim (e.g., water heated slower than soil), cites numeric evidence (ΔT and slope), and explains why using specific heat capacity and absorption/reflection. The peer feedback you gave was specific (e.g., ‘add units and trendline’) and improved your group’s model.”
Next step: Try adding error bars or a brief note on measurement uncertainty to strengthen analysis.
- Good (Score: 15–17/20):
“Your graph is mostly accurate; adjust the scale to avoid crowding at higher temperatures. Your CER has a clear claim and evidence; tighten your reasoning by naming the mechanism (e.g., water’s higher specific heat explains slower warming). Peer feedback is helpful—add one concrete suggestion.”
Revision: Re-label axes with units and add one sentence linking the data trend to specific heat.
- Needs Work (Score: 10–14/20):
“The graph needs corrected scaling and axis labels with units. Your CER is missing either the data citation or the mechanism. Peer feedback was general; provide one improvement your partner can act on.”
Revision: Redraw the graph with correct scales and add 2 data points to your CER with a mechanism (e.g., conduction into container walls).
- Incomplete (Score: 0–9/20):
“Key parts are missing (graph and/or CER). Submit a complete graph and CER to receive feedback.”

Summative (Energy Pathways Model + Justification)

- Excellent (Score: 28–30/30):
“Your model correctly traces radiation → absorption → conduction → convection with clear arrows, accurate labels, and a legend. The justification references your actual data (ΔT , rates) and connects color/absorption and material properties to observed heating differences.”
Next step: Add one real-world optimization (e.g., add reflective foil to increase radiation concentration).
- Good (Score: 24–27/30):
“The model is accurate overall; add labels to the convection arrows inside the greenhouse. Your justification mentions data—strengthen it with one numeric comparison and name the mechanism (specific heat vs.

conduction).”

Revision: Label missing arrows and add one precise ΔT comparison to the justification.

- Needs Work (Score: 18–23/30):

“The model confuses radiation and conduction in one area. The justification is vague or does not use class data.”

Revision: Relabel the pathway correctly and incorporate at least two measured values from your graph.

- Incomplete (Score: 0–17/30):

“Model or justification is missing. Submit both components for scoring.”

Differentiation, Modification(s), & Accommodation(s)

This unit intentionally differentiates learning activities based on students’ varied needs, aligning with Universal Design for Learning (UDL) and the rubric’s expectation for clear, activity-oriented connections to student diversity. Three or more activities are adapted using knowledge of students’ linguistic, cognitive, and behavioral profiles.

- **Representation Supports:**

Each lesson begins with a bilingual mini-glossary and visual concept map for key terms—radiation, conduction, convection, specific heat, and greenhouse effect—presented in English and students’ home languages. These resources include labeled diagrams and sentence frames for Claim–Evidence–Reasoning (CER), ensuring multilingual learners and students with literacy challenges access scientific vocabulary meaningfully. Captions and transcripts accompany all videos and PhET simulations to provide alternatives for auditory information, consistent with UDL checkpoints for perception and language support.

- **Action & Expression Options:**

Students choose how to present their heating-rate investigation: a video lab report, a poster with photos and graphs, or a typed document. Oral recordings are available for students with writing difficulties, and all formats embed CER frames. For engineering design, students may submit a slideshow, physical prototype, or narrated video. These choices reduce barriers for learners with ADHD and IEPs while maintaining rigor.

- **Engagement & Executive Function Supports:**

To scaffold organization, lessons include visual agendas, projected timers, and color-coded material bins. Lab stations use role cards (investigator, recorder, safety lead, presenter) to clarify tasks and promote equitable participation. Students with ADHD benefit from a two-minute “stop and check” routine before data collection, paired with a brief behavior report card for on-task monitoring. Predictable routines and positive reinforcement align with evidence-based strategies for attention and behavior regulation.

- **Scaffolds for Data Analysis:**

Pre-filled data tables and graph templates reduce cognitive load for students with executive function challenges.

Advanced learners receive enriched datasets with outliers and mixed units to deepen analysis and error-checking skills. They also engage in optional variable-control mini-studies and optimization proposals, providing authentic challenge without removing core access for others.

- **Accessibility & Safety:**

Lab spaces are decluttered, glassware is replaced with plastic, and adjustable-height workstations are provided for students with mobility needs. Safety protocols are modeled explicitly, and PPE is mandatory for heat and UV demonstrations. These universal design moves ensure physical accessibility and align with NSTA safety standards.

- **Behavioral & Self-Regulation Supports:**

Students with severe behavior disorders have access to a designated reflection space and metacognitive prompts during labs. Predictable cool-down routines and preferential seating prevent escalation and sustain engagement. These supports are embedded universally to avoid stigmatization.

- **Extensions for Gifted Learners:**

Honor students lead micro-investigations, mentor peers during calibration, and present expert commentaries synthesizing radiation, conduction, and convection interactions. They design optimization proposals for greenhouse efficiency, integrating quantitative reasoning and argument from evidence.

- This differentiation plan ensures that all learners—multilingual students, those with ADHD or IEPs, and advanced thinkers—experience equitable access to rigorous science learning while connecting solar energy and heat transfer concepts to lived experiences and sustainability challenges.

- **Classroom Environment & Grouping:** Desks are arranged in collaborative groups of four to promote peer learning and discourse. Seating assignments are informed by learning style and leadership quizzes, behavior records, and current academic performance to ensure balanced groups and targeted support. Students with visual impairments are positioned near the front for optimal visibility, while those requiring individualized assistance are seated close to the instructional teacher or co-teacher for immediate support.

- **Accessibility & Representation Supports:** English Learners and visual/auditory learners have access to video resources with closed captioning, translation options, and adjustable playback speed (e.g., Scientist Cindy’s instructional videos). Struggling readers and writers can use simplified interactive textbooks such as CK-12 Flexbook. These resources complement bilingual glossaries, visual concept maps, and captions provided during lessons, ensuring multiple means of representation.

- **Flexible Output & Expression:** For performance-based tasks—including the heating-rate investigation and engineering design challenge—students may choose from various formats such as video lab reports, posters, oral recordings, or physical models. Similarly, for extended projects, students can propose alternative formats (e.g.,

acting out concepts or creating digital presentations) with teacher approval. All outputs must meet core criteria for scientific reasoning and evidence-based explanation, maintaining rigor while honoring learner variability.

Online Resources for Differentiation

- English Learners & Visual/Auditory Learners Scientist: Cindy YouTube Lesson: Watch Video (Closed captioning, translations, adjustable speed) [growth of the human population - living in balance with the environment](#) and [What is Environmental Science?](#)
- Struggling Readers & Writers: Flexbook: Access Flexbook **20.11 Solar Energy** ([Solar Energy | CK-12 Foundation](#))
- Universal Design for Learning (UDL) Guidelines CAST UDL Guidelines: Explore UDL Framework [Support multiple ways to perceive information | CAST UDL Guidelines](#)
- ELL Strategy Library Colorín Colorado: Access ELL Strategies [ELL Glossary | Colorín Colorado](#)

Introduction: 20 minutes | Standards: GSE S6E4.b, NGSS MS-PS3-3

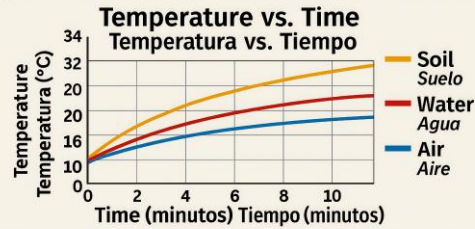
Anchoring Phenomenon: *Why does a greenhouse heat differently than the surrounding environment?*

Purpose: Move from observation to explanation by analyzing data and modeling energy flow.

Introduction (20 min)

- **Warm-Up (5 min):**
“Yesterday, we collected data on heating rates. Which material heated fastest? Why?”
- **Engage (10 min):**
Show a short PhET simulation or NASA Climate Kids clip on energy transfer.

Data Analysis Recap
 What pattern do you notice?
 ¿Qué patrón notas?



Prompts:

- Where do you see radiation, conduction, and convection?
- How do these processes interact in a greenhouse?

● **Canvas Discussion (5 min):**

1. What pattern do you notice in your graph?
2. How does this pattern connect to the greenhouse phenomenon?

Formative Assessment (Graphs + CER) – 20 pts

Criteria	Excellent (4 pts)	Good (3 pts)	Needs Work (1–2 pts)
Data Analysis Accuracy	Graph correct & labeled	Minor errors	Major errors
CER Writing	Claim, evidence, reasoning aligned	Missing detail	Unclear

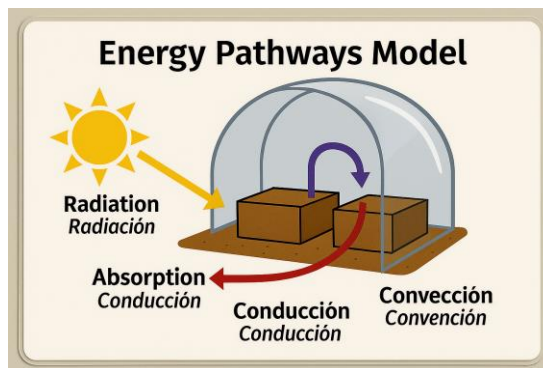
Participation	Fully engaged in peer feedback	Partial	Minimal
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Summative Assessment (Energy Pathways Model) – 30 pts

Criteria	Excellent (10 pts)	Good (8 pts)	Needs Work (5 pts)
Scientific Accuracy	All processes shown accurately	Minor inaccuracies	Major gaps
Visual Clarity	Neat, labeled, easy to interpret	Some labels missing	Disorganized
Justification	Connects model to data using CER	Partial	Weak reasoning

Body: 50 minutes

The body of the lesson begins with **Direct Instruction (10 minutes)** where the teacher projects visuals and short animations illustrating radiation, conduction, and convection.

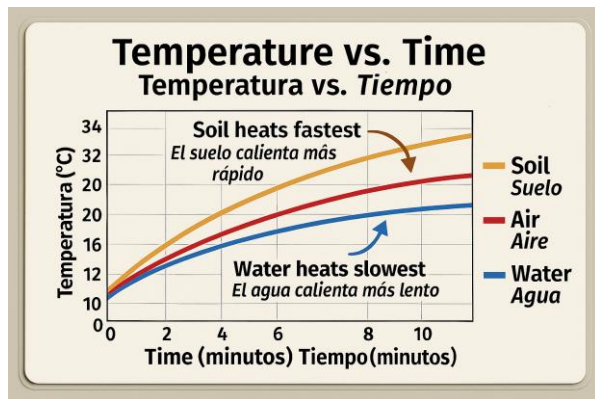


A bilingual glossary (English/Spanish) is introduced for key terms such as radiation/radiación, conduction/conducción, convection/convección, and specific heat/calor específico. The teacher models pronunciation and provides quick real-world

examples—sunlight warming skin for radiation, a pot on a stove for conduction, and warm air rising for convection—while using a think-aloud strategy to explain how energy moves in each case. Two quick comprehension checks follow: “Which process explains sunlight warming Earth?” and “Which process explains boiling water?”

Next, **Focused Instruction (15 minutes)** transitions students into analyzing the investigation data collected during Day 2. The teacher demonstrates how to organize temperature readings into tables and graphs, emphasizing accuracy and clarity. Students review fair-test principles and revisit laminated scenario cards showing energy transfer processes. The teacher narrates energy pathways—“Sunlight enters → soil absorbs → heat transfers to air by convection”—and connects these observations to the greenhouse phenomenon. Safety reminders are reinforced for handling materials and equipment. Students are prompted to predict patterns and justify their reasoning before moving to group work.

During **Guided Practice (15 minutes)**, students work collaboratively to graph their data using either graph paper or digital tools such as Google Sheets.



Groups post their graphs on a shared data wall for a gallery walk, using sentence frames like “I notice ___ because ___” and “One pattern is ___ which means ___.”

The teacher facilitates discussion by asking, “Which material shows the steepest slope? What does that tell us about heat absorption?” This activity builds analytical skills and prepares students for modeling energy pathways.

Finally, **Independent Practice (10 minutes)** requires students to write a Claim-Evidence-Reasoning (CER) statement explaining why certain materials heated faster than others.

CER Framework
Marco CER

Claim: Afirmación I claim that <i>_ because _</i>	
Afirmo que <i>_ porque _</i>	
Evidence: Evidencia My data shows <i>___</i>	
Mis datos muestran <i>___</i>	
Reasoning: Razonamiento	
This happens because <i>___</i> . <i>Esto ocurre porque _</i>	
✓ Name process (Radiation, Conduction, ✓ Cite ΔT from graph ✓ Explain mechanism (specific heat, absorption)	

Sentence frames are provided:

- **Claim:** I claim that *___* because *___*.
- **Evidence:** My data shows that *___* increased by *___*°C in *___* minutes.
- **Reasoning:** This happens because *___* has a higher/lower specific heat capacity than *___*.

Students reference their graphs and vocabulary wall to support their reasoning. CER responses are collected for formative assessment, ensuring students can connect data analysis to scientific principles.

Closing: 20 minutes

Day 3 Closing: Data Analysis & Energy Pathways Modeling

Summary:

In this 20-minute closing, students synthesize their data analysis and modeling work through a short PhET simulation, collaborative CER sharing, and a vocabulary review. The session concludes with an exit ticket submitted via Canvas, reinforcing concepts of radiation, conduction, and convection while previewing the next lesson—an engineering design challenge.

Connection to Day 1:

Day 1 introduced the anchoring phenomenon and the three modes of heat transfer through observation and prediction. Day 3 builds on that foundation by analyzing investigation data, constructing explanations, and modeling energy pathways to deepen understanding of how these processes interact in greenhouse systems.

Day 3 Anchoring Phenomenon**“Why does a greenhouse heat differently than the surrounding environment?”**

In the Day 3 closing, students link their data analysis and energy pathway models to the phenomenon by illustrating how radiation, absorption, conduction, and convection combine to create temperature differences inside the greenhouse.

Timing: 20 minutes total

Steps:

1. Transition (1–2 min): Teacher signals the end of data analysis and sets a visible timer for students to wrap up CER responses. Materials are cleared; students prepare for reflection.
2. Synthesis & Reflection (10 min): Quick Clip (PhET or NASA Climate Kids):
Show a short simulation or video illustrating heat transfer in greenhouse systems.
 - Prompts:
 - Where do you see radiation, conduction, and convection occurring?

Energy Pathways in a Greenhouse

Rutas de Energía en un Invernadero

<p>Why does a greenhouse heat differently than its surrounding environment? <i>¿Por qué un invernadero se calienta de manera diferente que su entorno?</i></p>		<p>Key vocabulario Radiation Radiación Conduction Conducción Convección Convección Absorción Absorción Reflexión Reflexión</p>
<p>Where do you see convection, conduction, and radiation occurring? <i>¿Dónde ves que ocurre la radiación, la conducción y la convección?</i></p>		<p>Sentence frame Claim: "I claim that ... because ..."</p>
<p>Crosscutting concepts: Energy & Matter <i>Energía y Materia</i> Systems & System Models <i>Sistemas y Modelos</i></p>	<p>Energy & Matter <i>Energía y Materia</i> Systems & System Models <i>Sistemas y Modelos</i></p>	<p>Evidencia: Mis datos muestran que ... aumentó ...°C en ... minutos.</p> <p>Reasoning: Esto ocurre porque ... tiene mayor/menor calor específico.</p>

- Identify three biotic and three abiotic factors that influenced heating during the investigation. This recap reinforces conceptual understanding and connects to the anchoring phenomenon: *Why do greenhouses heat differently than the surrounding environment?*

- CER Share (5–6 min): Students share CER statements in small groups, comparing evidence (graphs, data tables) and reasoning (specific heat, absorption, reflection). Each group identifies one key insight about how solar energy transfers heat to soil, water, and air. Teacher facilitates a brief whole-class discussion to synthesize insights and connect to sustainability and real-world applications.

CCC Focus: Energy & Matter; Systems & System Models; Cause & Effect

Return to Anchor: “How did analyzing patterns in your graphs and building energy pathway models deepen your explanation of why greenhouses heat differently than the surrounding environment?”

SEP Self-Check (2 minutes):

Which SEP did you use today? (Develop and Use Models; Analyze Data) What artifact shows your proficiency? (e.g., energy pathway model, graph, CER statement)

CCC Writing Prompt: (Canvas or Notebook)

Write two sentences:

- (a) *Describe the system boundary and components in your model (Systems & System Models).*
- (b) *Explain what caused the observed heating pattern (Cause & Effect).*

CCC Discussion Prompt: (Think-Pair-Share)

How does your model show energy flow (Energy & Matter)?

What design choices or material properties influenced heat transfer?"

- 4. Vocabulary Review & Exit Ticket (5 min): Vocabulary Terms: absorption, reflection, specific heat, thermal energy, albedo, energy transfer
Activity:
 - Match each term to its definition (Canvas Question Bank or card sort).
 - Use one term in a sentence about today's investigation.
- 5. **Exit Ticket (4min):** (Canvas or paper/audio alternative):
 - Which heat transfer process was most evident today? Cite data.
 - How might a solar cooker use the same principles?

SEP Self-Check (2 minutes):

Which Science and Engineering Practice did you use today? (e.g., Analyze Data, Develop Models, Argue from Evidence).
What artifact shows your proficiency? (graph, CER, model, prototype).

CCC Writing & Discussion Prompts:

- *Energy & Matter:* "Explain how energy flows through radiation, conduction, and convection in today's investigation."
- *Systems & System Models:* "Define the boundaries of our greenhouse system and list its components."
- *Cause & Effect:* "What caused the differences in heating rates among soil, water, and air?"

Preview Next Lesson: Engineering Design Challenge—students will apply these principles to build a device that maximizes or minimizes heat transfer.

Additional CCC Writing Prompts (Systems & Cause & Effect):

Write two sentences:

- (a) Define the boundary of our system (Systems & System Models).
- (b) Explain what caused faster heating (Cause & Effect).

DCI (Disciplinary Core Idea)

Energy from the Sun drives atmospheric and surface processes. Heat transfer occurs through radiation, conduction, and convection, influencing climate, weather, and engineered systems like greenhouses.

SEP (Science and Engineering Practices)

- Analyze and Interpret Data: Students interpret graphs and patterns from the greenhouse investigation.
- Develop and Use Models: Students construct energy pathway models showing interactions among radiation, conduction, and convection.
- Construct Explanations and Engage in Argument from Evidence: Students justify claims using CER and connect findings to scientific principles.

CCC (Crosscutting Concepts)

- Energy and Matter: Trace energy flow through radiation, conduction, and convection.
- Systems and System Models: Represent greenhouse system boundaries and components in models.
- Cause and Effect: Explain why heating rates differ among soil, water, and air.

Materials, Tech & Safety

Classroom Setup & Materials

A dedicated materials table is organized with all necessary items for the lesson, including handouts, worksheets, notebook paper, laminated cards, thermometers, soil/water containers, and safety goggles. All digital resources—such as instructions, videos, vocabulary slides, and exit ticket links—are uploaded to Canvas for easy access. Desks are arranged in groups of four to promote cooperative learning, with groups assigned based on students’ learning style quiz, leadership style quiz, behavior record, and current grade to ensure balanced collaboration.

Behavior Management

A bell system is used for individual misbehavior:

- **Green Bell:** First warning—student relocates to a different seat.
- **Yellow Bell:** Second warning—student moves to an isolated desk.
- **Red Bell:** Third warning—student is sent to the administrator.

For whole-class disruptions, the teacher will flicker the lights as a signal for students to return to seats and quiet down. Classroom norms are posted on a whiteboard charter and reinforced daily. Positive behavior is rewarded with bonus points or small incentives.

Instructional Support

The primary teacher circulates during work periods to monitor progress, answer questions, and ensure safety compliance, offering one-on-one assistance for students who are disengaged or need clarification. A visual timer is projected to manage transitions between activities and keep students on task. If a co-teacher is added later, they will assist with pulling students for individualized instruction, providing targeted support for students with IEPs or language needs, and helping manage behavior and facilitate small-group work.

Safety Protocols

For lessons involving lab experiments or demonstrations, students must follow NSTA safety guidelines signed by students and guardians during the first week of school. Personal Protective Equipment (PPE)—including safety goggles and gloves—is required when handling heat sources or soil/water samples. Heat lamps and electrical cords are monitored to prevent burns or tripping hazards. Students are reminded of no horseplay and proper handling of materials before starting any activity. Emergency procedures, including fire extinguisher location and evacuation routes, are reviewed at the start of lab-based lessons.

Accessibility & Equity

Adjustable-height workstations are provided for students with mobility needs. Paper or audio alternatives are offered for exit tickets and CER tasks for students with IEPs or literacy challenges. Bilingual glossaries and captions for videos are available to support multilingual learners.

Layered Texts and Other Materials

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

CK-12 Foundation. (n.d.). *Solar energy (20.11)—CK-12 Earth science for middle school*. <https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/20.11/primary/lesson/solar-power-ms-es/>

Colorín Colorado. (n.d.). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>

International Society for Technology in Education. (n.d.). *ISTE standards: Students*. <https://www.iste.org/standards/students>

My NASA Data. (n.d.). *Earth's energy budget—Lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>

NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*. <https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

References

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

CK-12 Foundation. (n.d.-b). *Solar energy (20.11)—CK-12 Earth science for middle school*. <https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/20.11/primary/lesson/solar-power-ms-es/>

Colorín Colorado. (n.d.-a). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>

Freire, P. (2018). *Pedagogy of the oppressed* (50th anniversary ed.). Bloomsbury Academic.

Georgia Department of Education. (n.d.). *Science – Georgia standards of excellence*. <https://www.gadoe.org/learning/science/>

International Society for Technology in Education. (n.d.). *ISTE standards: Students*. <https://iste.org/standards/students>

Love, B. L. (2019). *We want to do more than survive: Abolitionist teaching and the pursuit of educational freedom*. Beacon Press.

Muhammad, G. (2023). *Unearthing joy: A guide to culturally and historically responsive teaching and learning* (Foreword by Pharrell Williams). Scholastic.

My NASA Data. (n.d.). *Earth's energy budget—Lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>

NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

National Academies of Sciences, Engineering, and Medicine. (2017). *Seeing students learn science: Integrating assessment and instruction in the classroom*. National Academies Press. <https://doi.org/10.17226/23548>

National Academies Press. (2017). *Energy literacy: Essential principles and fundamental concepts for energy education* (Version 5.0). U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2017/07/f35/Energy_Literacy.pdf

National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy*. <https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>

National Renewable Energy Laboratory. (n.d.). *Education resources for students*. <https://www.nrel.gov/about/education-students-resources>

National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. <https://doi.org/10.17226/13165>

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press. <https://doi.org/10.17226/18290>

Palcik, J. (2021). *Science lab & prep area safety guidance resource*. Flinn Scientific. <https://www.flinnsci.com>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*. <https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

Science Buddies. (n.d.). *Investigate the greenhouse effect*. https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvSci_p047/environmental-science/what-is-the-greenhouse-effect

TeachEngineering. (n.d.-b). *Our sun and heat transfer basics: Heat it up!*. https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

United States Botanic Garden, National Center for Appropriate Technology, & City Blossoms. (2019). *Greenhouse manual: An introductory guide for educators*. <https://www.usbg.gov/greenhouse-manual>

Willard, T. (Ed.). (2014). *The NSTA quick-reference guide to the NGSS, K–12*. NSTA Press.

Day 4: Learning and Assessment Plan

Curriculum Standards GSE (Georgia Standards of Excellence) / National Curriculum Standards [Science - Georgia Standards of Excellence](#)

S6E4.b – *Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates.*

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- Upload CER statements or lab reports to Canvas for teacher feedback.

- Use PhET simulations for conceptual understanding.
- Submit work in multiple formats (video, poster, oral recording), which matches UDL principles.

Mode of Instruction Face to Face / Online Synchronous / Online Asynchronous / Hybrid

Learning Objective/Goal (s)

Students will:

- **Identity:** Connect design choices to cultural practices and community needs (e.g., cooking traditions, home insulation).
Prompt: “How does your design reflect real-world needs in your community?”
- **Skills:** Apply scientific principles to design, build, and test a prototype that maximizes or minimizes heat transfer; collect and analyze performance data; justify design choices using CER.
Prompt: “What steps did you take to ensure your design met the criteria and constraints?”
- **Intellect:** Reason about how radiation, conduction, and convection interact in engineered systems and how design features influence energy flow.
Prompt: “Which heat transfer process does your design target most, and why?”
- **Criticality:** Discuss equity in access to sustainable technologies and energy-efficient solutions.
Prompt: “Who benefits most from energy-saving designs? Who might be excluded?”
- **Joy:** Engage in creative, hands-on design and celebrate innovation through peer critique and sharing.
Prompt: “What part of building your prototype was most exciting for you?”

Science and Engineering Practices (SEPs):

- Apply Scientific Principles to Design Solutions: Students design and justify prototypes to maximize or minimize heat transfer.
- Engage in Argument from Evidence: Students defend design choices using scientific reasoning and peer feedback.

Anchoring Phenomenon:

“Why does a greenhouse heat differently than the surrounding environment?”

Students will apply this question to justify how their design choices optimize or modify heat transfer for sustainability.

Sentence Frame (Cause & Effect in Design):

“Which design feature most influenced heat transfer? Explain using evidence.”

Formative and Summative Assessment

Formative: Design planning checklist, peer review of prototypes, observation notes during testing. Summative: Design Prototype & Presentation (slideshow, video, or physical model) with rubric for creativity, data-driven justification, and scientific accuracy.

Formative Assessment

Criteria	Excellent 20	Good 11	Needs Work 5	Incomplete 0
Design Planning	Detailed and feasible	Some details missing	Lacks clarity	Not attempted
Prototype Construction	Fully functional	Minor issues	Incomplete	Not built
Peer Review	Constructive feedback provided	Some feedback	Minimal feedback	Absent

Summative Assessment

Criteria	Excellent 30	Good 24	Needs Work 18	Incomplete 0
Creativity & Innovation	Original design addressing challenge	Some creativity	Basic design	Not submitted
Data-Driven Justification	Uses test data to support design	Partial data use	Weak evidence	No justification
Communication	Clear, organized, scientific vocabulary	Mostly clear	Unclear	Not presented

Formative (Design Plan + Build + Peer Review)

- Excellent (Score: 18–20/20):

“Your plan defines criteria (target ΔT in 15 min, safety threshold) and constraints (materials, time). The prototype is safe and functional; you collected consistent multi-trial data (every 2 min). Peer feedback was specific and

improved airflow control.”

Next step: Add a small insulation layer to limit convective losses; re-test and compare ΔT .

- Good (Score: 15–17/20):
“The plan is clear but missing one constraint (e.g., allowable max temperature). Prototype works; standardize your time intervals. Peer feedback was helpful—add one suggestion about reflective surfaces.”
Revision: Specify a max temperature and re-run with equal intervals; add reflective advice to peer notes.
- Needs Work (Score: 10–14/20):
“Plan lacks detail on criteria/constraints; prototype has safety or function issues. Data collection is inconsistent (uneven intervals); peer feedback was minimal.”
Revision: Define criteria and constraints, correct safety issue, collect 3 consistent trials.
- Incomplete (Score: 0–9/20):
“Plan/prototype does not meet minimum requirements; submit a revised plan and basic build.”

Summative (Prototype & Presentation)

- Excellent (Score: 28–30/30):
“Your design clearly maximizes/minimizes heat transfer (e.g., black interior for absorption, double-wall insulation to limit conduction, baffles/vents to manage convection). You justify choices with test data (ΔT , rise time) and communicate clearly with visuals and correct vocabulary.”
Next step: Include a brief cost/benefit note on materials and performance.
- Good (Score: 24–27/30):
“Design works with minor shortcomings; your justification references data, but analysis could compare pre/post modifications. Presentation is mostly clear; add one labeled diagram.”
Revision: Insert a pre/post ΔT comparison and a labeled sectional diagram.
- Needs Work (Score: 18–23/30):
“Design is basic or does not explicitly address a heat-transfer mechanism. Data is limited or analysis is weak; presentation lacks organization.”
Revision: Identify the mechanism (radiation/conduction/convection) your design targets; re-test and add one plotted graph.
- Incomplete (Score: 0–17/30):
“Prototype or presentation missing. Submit both pieces for assessment.”

Differentiation, Modification(s), & Accommodation(s)

This unit intentionally differentiates learning activities based on students' varied needs, aligning with Universal Design for Learning (UDL) and the rubric's expectation for clear, activity-oriented connections to student diversity. Three or more activities are adapted using knowledge of students' linguistic, cognitive, and behavioral profiles.

Representation Supports:

Each lesson begins with a bilingual mini-glossary and visual concept map for key terms—radiation, conduction, convection, specific heat, and greenhouse effect—presented in English and students' home languages. These resources include labeled diagrams and sentence frames for Claim–Evidence–Reasoning (CER), ensuring multilingual learners and students with literacy challenges access scientific vocabulary meaningfully. Captions and transcripts accompany all videos and PhET simulations to provide alternatives for auditory information, consistent with UDL checkpoints for perception and language support.

Action & Expression Options:

Students choose how to present their heating-rate investigation: a video lab report, a poster with photos and graphs, or a typed document. Oral recordings are available for students with writing difficulties, and all formats embed CER frames. For engineering design, students may submit a slideshow, physical prototype, or narrated video. These choices reduce barriers for learners with ADHD and IEPs while maintaining rigor.

Engagement & Executive Function Supports:

To scaffold organization, lessons include visual agendas, projected timers, and color-coded material bins. Lab stations use role cards (investigator, recorder, safety lead, presenter) to clarify tasks and promote equitable participation. Students with ADHD benefit from a two-minute “stop and check” routine before data collection, paired with a brief behavior report card for on-task monitoring. Predictable routines and positive reinforcement align with evidence-based strategies for attention and behavior regulation.

Scaffolds for Data Analysis:

Pre-filled data tables and graph templates reduce cognitive load for students with executive function challenges. Advanced learners receive enriched datasets with outliers and mixed units to deepen analysis and error-checking skills. They also engage in optional variable-control mini-studies and optimization proposals, providing authentic challenge without removing core access for others.

Accessibility & Safety:

Lab spaces are decluttered, glassware is replaced with plastic, and adjustable-height workstations are provided for students with mobility needs. Safety protocols are modeled explicitly, and PPE is mandatory for heat and UV demonstrations. These universal design moves ensure physical accessibility and align with NSTA safety standards.

Behavioral & Self-Regulation Supports:

Students with severe behavior disorders have access to a designated reflection space and metacognitive prompts during

labs. Predictable cool-down routines and preferential seating prevent escalation and sustain engagement. These supports are embedded universally to avoid stigmatization.

Extensions for Gifted Learners:

Honor students lead micro-investigations, mentor peers during calibration, and present expert commentaries synthesizing radiation, conduction, and convection interactions. They design optimization proposals for greenhouse efficiency, integrating quantitative reasoning and argument from evidence.

This differentiation plan ensures that all learners—multilingual students, those with ADHD or IEPs, and advanced thinkers—experience equitable access to rigorous science learning while connecting solar energy and heat transfer concepts to lived experiences and sustainability challenges.

Classroom Environment & Grouping: Desks are arranged in collaborative groups of four to promote peer learning and discourse. Seating assignments are informed by learning style and leadership quizzes, behavior records, and current academic performance to ensure balanced groups and targeted support. Students with visual impairments are positioned near the front for optimal visibility, while those requiring individualized assistance are seated close to the instructional teacher or co-teacher for immediate support.

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Flexible Output & Expression: For performance-based tasks—including the heating-rate investigation and engineering design challenge—students may choose from various formats such as video lab reports, posters, oral recordings, or physical models. Similarly, for extended projects, students can propose alternative formats (e.g., acting out concepts or creating digital presentations) with teacher approval. All outputs must meet core criteria for scientific reasoning and evidence-based explanation, maintaining rigor while honoring learner variability.

Online Resources for Differentiation

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- ELL Strategy Library Colorín Colorado: Access ELL Strategies [ELL Glossary](#) | [Colorín Colorado](#)

Introduction: 20 minutes | **Standards: GSE S6E4.b, NGSS MS-PS3-3**

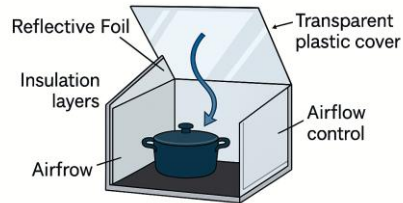
Anchoring Phenomenon: *Why does a greenhouse heat differently than the surrounding environment?*

Purpose: Apply scientific principles to design a device that maximizes or minimizes heat transfer.

Introduction (20 min)

Warm-Up Video (10 min):

Day 4 – Engineering Design Challenge



Safety icons



Show solar oven or insulation prototype demo.

Prompts:

- Which heat transfer process does this design target?
- How could this help communities reduce energy costs?

Canvas Discussion (5 min):

- What design feature seems most effective?
- How might this design improve sustainability?

Vocabulary (5 min):

Radiation / Radiación, Conduction / Conducción, Convection / Convección, Insulation / Aislamiento, Prototype / Prototipo.

Formative Assessment (Design Plan + Peer Review) – 20 pts

Criteria	Excellent (4 pts)	Good (3 pts)	Needs Work (1–2 pts)
Design Planning	Detailed & feasible	Some details missing	Lacks clarity
Peer Feedback	Constructive & specific	Minimal	None
Safety Compliance	Fully observed	Minor lapses	Unsafe

Summative Assessment (Prototype & Presentation) – 30 pts

Criteria	Excellent (10 pts)	Good (8 pts)	Needs Work (5 pts)
Creativity & Innovation	Original design addressing challenge	Some creativity	Basic design
Data-Driven Justification	Uses test data to support design	Partial	Weak evidence
Communication	Clear, organized, scientific vocabulary	Mostly clear	Unclear

Body: 50 minutes

Direct Instruction (10 min):

- Review heat transfer principles and introduce **criteria and constraints** for the design challenge:
 - Must use available classroom materials.
 - Must demonstrate at least two heat transfer principles.
 - Must meet safety guidelines.

Focused Instruction (15 min):

- Show examples of solar ovens and insulation prototypes.
- Discuss optimization strategies: reflective surfaces, insulation layers, airflow control.
- Model how to create a **design plan** using a template (criteria, constraints, materials list, predicted outcome).

Day 4 Anchoring Phenomenon

“Why does a greenhouse heat differently than the surrounding environment?”

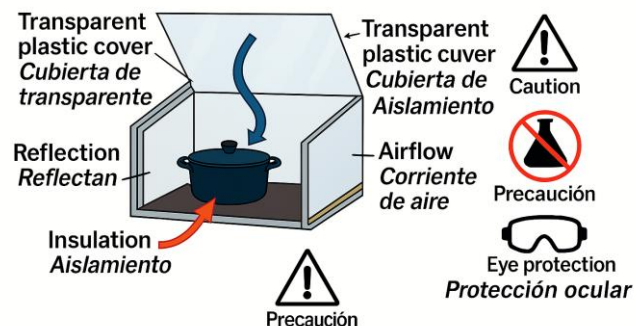
In the Day 4 closing, students reference the phenomenon when justifying how their engineering design choices (e.g., insulation, reflective surfaces, airflow control) optimize heat transfer to replicate or modify greenhouse heating patterns for sustainability.

Timing: 20 minutes total

Steps:

1. **Transition (1–2 min):** Signal end of building phase; students clear materials and prepare for reflection.

Solar Oven Design Diseño de un Horno Solar



2. **Synthesis & Reflection (10 min):** Quick Clip (PhET or NASA Climate Kids):
Show a short simulation or video illustrating energy transfer in engineered systems.
 - Guiding Questions:
 - Which heat transfer process does your design target most?
 - How could this design help communities reduce energy costs?

Focus: Energy & Matter; Systems & System Models; Cause & Effect

Return to Anchor: How did your design choices for maximizing or minimizing heat transfer connect to the question: Why do greenhouses heat differently than the surrounding environment?

SEP Self-Check (2 minutes):

Which SEP did you use today? (Apply Scientific Principles; Argue from Evidence) What artifact shows your proficiency? (e.g., prototype, design plan, test data)

CCC Writing Prompt:

Write two sentences:

(a) *Explain how your design changes energy flow (Energy & Matter).*

(b) *Describe the cause-and-effect relationship between one design feature and heat transfer.*

CCC Discussion Prompt:

How does your prototype represent the system (Systems & System Models)?

Which feature most impacts energy transfer and why?"

3. Peer Critique (5 min): Groups share one design feature and explain how it optimizes heat transfer. Teacher facilitates discussion connecting design strategies to scientific principles and equity considerations.

4. Exit Ticket (5 min): Submit via Canvas or audio alternative:

- Which principle (radiation, conduction, convection) was most important in your design?
- How might your design improve sustainability in real-world contexts?
-

SEP Self-Check (2 minutes):

Which Science and Engineering Practice did you use today? (e.g., Analyze Data, Develop Models, Argue from Evidence). What artifact shows your proficiency? (graph, CER, model, prototype).

CCC Writing & Discussion Prompts:

- *Energy & Matter:* "Explain how energy flows through radiation, conduction, and convection in today's investigation."
- *Systems & System Models:* "Define the boundaries of our greenhouse system and list its components."

- *Cause & Effect*: “What caused the differences in heating rates among soil, water, and air?”

Preview Next Lesson: Tomorrow, we’ll test prototypes, collect data, and present findings with CER justification.

DCI (Disciplinary Core Idea)

Energy from the Sun drives thermal processes. Engineering design applies principles of radiation, conduction, and convection to optimize energy transfer for sustainability.

SEP (Science and Engineering Practices)

- Apply Scientific Principles to Design Solutions: Students design and justify prototypes to maximize or minimize heat transfer.
- Engage in Argument from Evidence: Students defend design choices using scientific reasoning and peer feedback.

CCC (Crosscutting Concepts)

- Energy and Matter: Optimize energy flow in engineered systems.
- Cause and Effect: Explain how design features influence heat transfer.
- Systems and System Models: Represent design constraints and energy pathways.

Materials, Tech & Safety

Classroom Setup & Materials

- A dedicated materials table is organized with all necessary items for the lesson (handouts, worksheets, notebook paper, laminated cards, thermometers, soil/water containers, and safety goggles).
- All digital resources (instructions, videos, vocabulary slides, and exit ticket links) are uploaded to Canvas for easy access.
- Desks are arranged in groups of four to promote cooperative learning. Groups are assigned based on students’ learning style quiz, leadership style quiz, behavior record, and current grade to ensure balanced collaboration.

Behavior Management

- A bell system is used for individual misbehavior:
 - Green Bell: First warning—student relocates to a different seat.
 - Yellow Bell: Second warning—student moves to an isolated desk.
 - Red Bell: Third warning—student is sent to the administrator.

- For whole-class disruptions, the teacher will flicker the lights as a signal for students to return to seats and quiet down.
- Classroom norms are posted on a whiteboard charter and reinforced daily. Positive behavior is rewarded with bonus points or small incentives.

Instructional Support

- Currently, the primary teacher provides all support:
 - Circulate during work periods to monitor progress, answer questions, and ensure safety compliance.
 - Offer one-on-one assistance for students who are disengaged or need clarification.
- A visual timer is projected to manage transitions between activities, helping students stay on task.
- If a co-teacher is added later, they will assist with:
 - Pulling students for individualized instruction.
 - Providing targeted support for students with IEPs or language needs.
 - Helping manage behavior and facilitate small-group work.

Safety Protocols

- For lessons involving lab experiments or demonstrations, students must follow NSTA safety guidelines signed by students and guardians during the first week of school.
- Personal Protective Equipment (PPE): Safety goggles and gloves are required when handling heat sources or soil/water samples.
- Heat lamps and electrical cords are monitored to prevent burns or tripping hazards.
- Students are reminded of no horseplay and proper handling of materials before starting any activity.
- Emergency procedures (fire extinguisher location, evacuation routes) are reviewed at the start of lab-based lessons.

Accessibility & Equity

- Provide adjustable-height workstations for students with mobility needs.
- Offer paper or audio alternatives for exit tickets and CER tasks for students with IEPs or literacy challenges.
- Ensure bilingual glossaries and captions for videos to support multilingual learners.

Layered Texts and Other Materials

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

CK-12 Foundation. (n.d.). *Biology flexbook*. <https://flexbooks.ck12.org>

Colorín Colorado. (n.d.). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>

National Aeronautics and Space Administration (NASA) Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*.
<https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>
TeachEngineering. (n.d.). *Cooking with the sun—Creating a solar oven*.
https://www.teachengineering.org/activities/view/duk_solaroven_tech_act
U.S. Department of Energy. (2017). *Energy literacy: Essential principles and fundamental concepts for energy education* (Version 5.0). https://www.energy.gov/sites/prod/files/2017/07/f35/Energy_Literacy.pdf

References

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>
CK-12 Foundation. (n.d.-b). *Solar energy (20.11)—CK-12 Earth science for middle school*.
<https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/20.11/primary/lesson/solar-power-ms-es/>
Colorín Colorado. (n.d.-a). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>
Freire, P. (2018). *Pedagogy of the oppressed* (50th anniversary ed.). Bloomsbury Academic.
Georgia Department of Education. (n.d.). *Science – Georgia standards of excellence*.
<https://www.gadoe.org/learning/science/>
International Society for Technology in Education. (n.d.). *ISTE standards: Students*. <https://iste.org/standards/students>
Love, B. L. (2019). *We want to do more than survive: Abolitionist teaching and the pursuit of educational freedom*. Beacon Press.
Muhammad, G. (2023). *Unearthing joy: A guide to culturally and historically responsive teaching and learning* (Foreword by Pharrell Williams). Scholastic.
My NASA Data. (n.d.). *Earth's energy budget—Lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>
NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>
National Academies of Sciences, Engineering, and Medicine. (2017). *Seeing students learn science: Integrating assessment and instruction in the classroom*. National Academies Press. <https://doi.org/10.17226/23548>
National Academies Press. (2017). *Energy literacy: Essential principles and fundamental concepts for energy education* (Version 5.0). U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2017/07/f35/Energy_Literacy.pdf
National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy*.
<https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>
National Renewable Energy Laboratory. (n.d.). *Education resources for students*. <https://www.nrel.gov/about/education-students-resources>

National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. <https://doi.org/10.17226/13165>

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press. <https://doi.org/10.17226/18290>

Palcik, J. (2021). *Science lab & prep area safety guidance resource*. Flinn Scientific. <https://www.flinnsci.com>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*. <https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

Science Buddies. (n.d.). *Investigate the greenhouse effect*. https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvSci_p047/environmental-science/what-is-the-greenhouse-effect

TeachEngineering. (n.d.-b). *Our sun and heat transfer basics: Heat it up!*. https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

United States Botanic Garden, National Center for Appropriate Technology, & City Blossoms. (2019). *Greenhouse manual: An introductory guide for educators*. <https://www.usbg.gov/greenhouse-manual>

Willard, T. (Ed.). (2014). *The NSTA quick-reference guide to the NGSS, K–12*. NSTA Press.

Day 5: Learning and Assessment Plan

Curriculum Standards GSE (Georgia Standards of Excellence) / National Curriculum Standards Science - Georgia Standards of Excellence

S6E4.b – Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land, and water at different rates.

ISTE Technology Standard

<https://www.iste.org/standards/for-students>

ISTE 1.1.c emphasizes seeking feedback through technology and demonstrating learning in varied ways. This is more aligned with the instructional design for Day 2 because students will:

- Upload CER statements or lab reports to Canvas for teacher feedback.
- Use PhET simulations for conceptual understanding.
- Submit work in multiple formats (video, poster, oral recording), which matches UDL principles.

Mode of Instruction Face to Face / Online Synchronous / Online Asynchronous / Hybrid

Learning Objective/Goal(s)

Students will:

- **Identity:** Reflect on personal and community connections to energy use and sustainability through discussion and written reflection.
Prompt: “Where do you see these concepts in your family or community?”
- **Skills:** Communicate scientific ideas clearly through presentations, CER writing, and summative assessments; compare models and design strategies.
Prompt: “What evidence supports your strongest claim about heat transfer?”
- **Intellect:** Analyze how heat transfer principles apply to real-world challenges and future innovations.
Prompt: “How does understanding energy flow help communities design sustainable solutions?”
- **Criticality:** Evaluate who benefits from energy-efficient technologies and propose solutions for equity.
Prompt: “What changes could make these technologies more accessible?”
- **Joy:** Celebrate learning through interactive review games, creative presentations, and community-oriented action proposals.
Prompt: “What part of this week’s learning brought you the most joy?”

Science and Engineering Practices (SEPs):

- Synthesize and Communicate Information: Students consolidate findings from investigations and design challenges.
- Engage in Argument from Evidence: Students justify solutions for sustainability and equity using scientific reasoning.

Anchoring Phenomenon:

“Why does a greenhouse heat differently than the surrounding environment?”

Students will synthesize evidence from investigations and design challenges to explain this phenomenon and connect it to sustainability and equity.

Sentence Frame (Stability & Change):

“How did energy transfer concepts apply to sustainability solutions?”

Formative and Summative Assessment

Formative: Exit ticket on real-world application of heat transfer, group discussion comparing models. Summative: Unit Quiz and written reflection connecting heat transfer to sustainability and equity.

Formative Assessment

Criteria	Excellent 10	Good 7	Needs Work 5	Incomplete 0
Exit Ticket	Accurate identification of application	Mostly accurate	Partially correct	Not attempted
Group Discussion	Active participation	Partial participation	Minimal	Absent

Summative Assessment

Criteria	Excellent 30	Good 24	Needs Work 18	Incomplete 0
Concept Mastery	Thorough understanding of concepts	Minor gaps	Major gaps	No understanding
Depth of Reflection	Connects to sustainability & equity	Partial connection	Superficial	Not submitted
Clarity & Mechanics	Coherent and error-free	Few errors	Many errors	Unreadable

Formative (Exit Ticket + Discussion)

- Excellent (Score: 9–10/10):
“You identify a real-world application (e.g., home insulation or solar cooker), cite lesson data, and accurately describe how radiation, conduction, and convection interact. In discussion, you build on peers’ models with evidence.”
 Next step: Propose a design tweak that improves efficiency.
- Good (Score: 7–8/10):
“You name an application and connect it to concepts; add one piece of data or mechanism detail to strengthen your

explanation.”

Revision: Cite one ΔT value and name the mechanism involved.

- Needs Work (Score: 5–6/10):

“Application is vague or not connected to mechanisms; discussion participation limited.”

Revision: Write one sentence for each mechanism (radiation, conduction, convection) in the application.

- Incomplete (Score: 0–4/10):

“Exit ticket missing; please submit.”

Summative (Quiz + Reflection)

- Excellent (Score: 28–30/30):

“Quiz shows mastery of heat-transfer modes and their interactions; reflection connects learning to sustainability and equity (e.g., access to energy-efficient tech) with clear, well-edited writing.”

Next step: Suggest one community-facing action (school greenhouse efficiency, home weatherization).

- Good (Score: 24–27/30):

“Strong understanding with minor misconceptions; reflection links to sustainability but needs deeper analysis or an example.”

Revision: Correct the misconception (e.g., *dark color increases absorption, not ‘creates heat’*), add a lived example.

- Needs Work (Score: 18–23/30):

“Concept gaps remain (confusing radiation vs. conduction); reflection is superficial.”

Revision: Revisit the Energy Pathways Model and rewrite a paragraph distinguishing each mode in your example.

- Incomplete (Score: 0–17/30):

“Quiz or reflection missing; submit to receive feedback.”

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- Struggling Readers & Writers: Flexbook: Access Flexbook **20.11 Solar Energy** ([Solar Energy | CK-12 Foundation](#))
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- ELL Strategy Library Colorín Colorado: Access ELL Strategies [ELL Glossary | Colorín Colorado](#)

Introduction: 20 minutes | Standards: GSE S6E4.b, NGSS MS-PS3-3

Phenomena warm-up (5 min)

- Short video: What is the Greenhouse Effect? (NASA Climate Kids). Prompt: “Where do you see radiation, conduction, and convection at work?” [\[climatekids.nasa.gov\]](http://climatekids.nasa.gov)

Day 5 – Reflection & Assessment

Why does a greenhouse heat differently than its surrounding environment?
¿Por qué un invernadero se calienta de manera diferente que su entorno?

Synthesize Findings
Sintetizar los Hallazgos

- Present conclusions
- Comparar modelos
- Reflect on sobre los tres modos de transferencia de calor

Conclusion Here / *Conclusión aquí*

Model Comparison Here
Comparación de modelos aquí

Reflection Here
Reflexión aquí

Key Vocabulary / Vocabulario Clave
Greenhouse / Invernadero
Conducción / Conducción
Efficiency / Eficiencia

- Scaffold: Bilingual mini-glossary slide (English/Spanish) for radiation / radiación; conduction / conducción; convection / convección; greenhouse effect / efecto invernadero.

Retrieval + Set the Purpose (10 min)

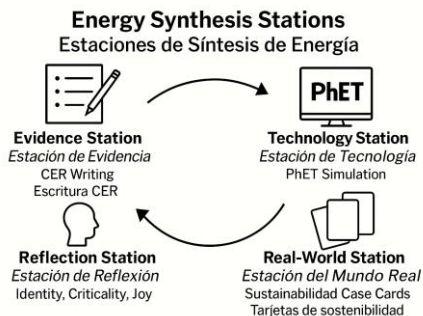
- Think–Pair–Share: “From our Day 2–4 work, what one design feature best minimized or maximized heat transfer? Why?” (anchor to NGSS MS-PS3-3). [nextgenscience.org]
- Teacher prompt: “Today you’ll synthesize your evidence, present your strongest claim, and connect it to sustainability and equity.”

Agenda + UDL options (5 min)

- Students choose presentation modality (slide, poster, audio/video) and language supports (sentence frames, bilingual captions). This fulfills ISTE 1.6 (choose platforms, adapt message to audience). [iste.org]

Body: 50 minutes

Station Rotations (4 × ~10–12 min) — Synthesis & Application



Evidence Station

- Teams compile one-page CER using their data (ΔT graphs, heating-rate tables) to explain how radiation → absorption → conduction → convection produced their outcomes in the greenhouse and design challenge.
- Quick reference: CK-12 Solar Energy overview for radiation and conduction examples. [\[flexbooks.ck12.org\]](https://flexbooks.ck12.org)

Technology & Modeling Station

- Students run a short PhET heat/thermo sim to visualize energy transfer pathways; they capture a screenshot + 2-sentence caption connecting the sim to their device or greenhouse findings. [\[phet.colorado.edu\]](https://phet.colorado.edu)
- Extension team: Explore NASA My NASA Data “Earth’s Energy Budget” mini-lesson to connect shortwave/longwave radiation to greenhouse performance; note one classroom implication. [\[mynasadata...c.nasa.gov\]](https://mynasadata.nasa.gov)

Real-World Sustainability Station

- Case cards: “Home HVAC,” “Car Interiors,” “Solar Oven,” “Community Greenhouse” (students map which mode dominates where, then propose one improvement rooted in equity—e.g., low-cost insulation or reflective surfaces).
- For solar ovens, reference the TeachEngineering activity (design choices: absorption, insulation; testing with periodic temperature measurement). [\[teachengineering.org\]](https://teachengineering.org)

Reflection & HRL Station

- Short write/audio: Identity (“Where do I see these concepts in my family/community?”), Criticality (“Who has access to efficient tech? What solution is possible here?”), Joy (“What part of the week energized me?”).
- Submission options meet UDL: multimodal expression; captioned audio; bilingual stems. CAST UDL framework supports varied representation and expression. [\[cast.org\]](https://cast.org)

Mini-presentations (10–12 min total, woven into rotations)

- Each group shares a 60–90 sec defense:
 - Claim: Our device/greenhouse remained stable or improved efficiency under ___ condition.
 - Evidence: Graph + ΔT values (before/after).
 - Reasoning: Explicitly name radiation/conduction/convection interactions.
- ISTE 1.6 emphasis: choose a communication platform; tailor visuals to audience (labels, captions). [iste.org](https://www.iste.org/)

Summative Quiz (last 12–15 min of the Body)

- Short mastery check (mix of item types): identify dominant heat-transfer mode in scenarios, interpret a small temperature-time graph, choose a design change to minimize conduction or maximize absorption.
- Items reference phenomena consistent with GSE S6E4.b and MS-PS3-3 tasks. media.cobbk12.org, nextgenscience.org

Closing: 20 minutes

Day 5 Closing: Synthesis, Reflection & Assessment

Summary:

In this 20-minute closing, students synthesize their learning from the entire unit, reflect on sustainability applications, and demonstrate mastery through discussion and an exit ticket. This closing reinforces connections between heat transfer principles and real-world equity issues while previewing the next unit on microclimates and energy budgets.

Connection to Day 4:

Day 4 focused on applying heat transfer principles in engineering design. Day 5 builds on that by consolidating evidence from investigations and prototypes, engaging in reflective discourse, and connecting science learning to community-based solutions.

Anchoring Phenomenon Link:

Today’s reflection ties back to the question: *Why does a greenhouse heat differently than its surrounding environment?* Students use this phenomenon to explain how their designs and findings address sustainability and equity.

Timing: 20 minutes total

1. **Transition (1–2 min):** Signal end of presentations and prototype testing; students clear materials and prepare for reflection.

Day 5 – Reflection & Assessment

Why does a greenhouse heat differently than its surrounding environment?
¿Por qué un invernadero se calienta de manera diferente que su entorno?

Synthesize Findings

Sintetizar los Hallazgos

- Present conclusions
- Compare models
- Reflect on sobre los tres modos de transferencia de calor

Conclusion Here / *Conclusión aquí*

Model Comparison Here
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Key Vocabulary / *Vocabulario Clave*

Greenhouse / *Invernadero*
Conduction / *Conducción*
Efficiency / *Eficiencia*

2. **Synthesis & Reflection (8 min):** Community Circle Discussion:

○ Prompt:

- “One way we’ll apply our learning for justice (food deserts, energy costs) is _____.”
- Students propose school-site actions (e.g., greenhouse shade strategies, low-cost insulation, reflective films). Teacher connects ideas to sustainability and equity.

CCC Focus: Energy & Matter; Cause & Effect; Stability and Change

Return to anchor: How does your final explanation of greenhouse heating connect to what we will study next about weather and microclimates?

SEP Self-Check (2 minutes):

Which SEP did you use today? (Construct Explanations; Communicate Information) What artifact shows your proficiency? (e.g., CER reflection, presentation, quiz)

CCC Writing Prompt:

Write two sentences:

- (a) *Explain how energy flow connects to sustainability (Energy & Matter).*
- (b) *Describe one change that improves equity in energy-efficient design (Stability and Change).*

CCC Discussion Prompt:

How do your findings show cause-and-effect relationships between design choices and community outcomes?

What system-level changes could make energy-efficient solutions more accessible?”

3. Exit Ticket (7 min): Submit via Canvas or audio alternative:

- In your application scenario, which process (radiation, conduction, convection) matters most? Use one data point or observation.
- Name a low-cost change that increases fairness (access to fresh foods / lower energy bills) and explain how it works physically.

SEP Self-Check (2 minutes):

Which Science and Engineering Practice did you use today? (e.g., Analyze Data, Develop Models, Argue from Evidence).
What artifact shows your proficiency? (graph, CER, model, prototype).

CCC Writing & Discussion Prompts:

- *Energy & Matter:* “Explain how energy flows through radiation, conduction, and convection in today’s investigation.”
- *Systems & System Models:* “Define the boundaries of our greenhouse system and list its components.”
- *Cause & Effect:* “What caused the differences in heating rates among soil, water, and air?”

Preview Next Unit (5 min)

- Introduce Microclimates & Energy Budgets: “How does unequal heating drive local weather?”

- Optional teaser: NASA Energy Budget map—what regions appear net warming/cooling?

DCI (Disciplinary Core Idea)

Integration of heat transfer principles with real-world sustainability challenges. Understanding energy flow helps communities design equitable and efficient solutions.

SEP (Science and Engineering Practices)

- Synthesize and Communicate Information: Students consolidate findings from investigations and design challenges.
- Engage in Argument from Evidence: Students justify solutions for sustainability and equity using scientific reasoning.

CCC (Crosscutting Concepts)

- Stability and Change: Evaluate how energy transfer concepts apply to sustainable systems.
- Cause and Effect: Explain how proposed changes influence energy efficiency and community outcomes.
- Energy and Matter: Connect energy flow to real-world applications like food systems and housing.

Facilitation & Safety

Classroom Setup & Materials

- A dedicated materials table is organized with all necessary items for the lesson (handouts, worksheets, notebook paper, laminated cards, thermometers, soil/water containers, and safety goggles).
- All digital resources (instructions, videos, vocabulary slides, and exit ticket links) are uploaded to Canvas for easy access.
- Desks are arranged in groups of four to promote cooperative learning. Groups are assigned based on students' learning style quiz, leadership style quiz, behavior record, and current grade to ensure balanced collaboration.

Behavior Management

- A bell system is used for individual misbehavior:
 - Green Bell: First warning—student relocates to a different seat.
 - Yellow Bell: Second warning—student moves to an isolated desk.
 - Red Bell: Third warning—student is sent to the administrator.
- For whole-class disruptions, the teacher will flicker the lights as a signal for students to return to seats and quiet down.
- Classroom norms are posted on a whiteboard charter and reinforced daily. Positive behavior is rewarded with bonus points or small incentives.

Instructional Support

- Currently, the primary teacher provides all support:
 - Circulate during work periods to monitor progress, answer questions, and ensure safety compliance.
 - Offer one-on-one assistance for students who are disengaged or need clarification.
- A visual timer is projected to manage transitions between activities, helping students stay on task.
- If a co-teacher is added later, they will assist with:
 - Pulling students for individualized instruction.
 - Providing targeted support for students with IEPs or language needs.
 - Helping manage behavior and facilitate small-group work.

Safety Protocols

- For lessons involving lab experiments or demonstrations, students must follow NSTA safety guidelines signed by students and guardians during the first week of school.
- Personal Protective Equipment (PPE): Safety goggles and gloves are required when handling heat sources or soil/water samples.
- Heat lamps and electrical cords are monitored to prevent burns or tripping hazards.
- Students are reminded of no horseplay and proper handling of materials before starting any activity.
- Emergency procedures (fire extinguisher location, evacuation routes) are reviewed at the start of lab-based lessons.

Accessibility & Equity

- Provide adjustable-height workstations for students with mobility needs.
- Offer paper or audio alternatives for exit tickets and CER tasks for students with IEPs or literacy challenges.
- Ensure bilingual glossaries and captions for videos to support multilingual learners.

Layered Texts and Other Materials

CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>

CK-12 Foundation. (n.d.). *Biology flexbook*. <https://flexbooks.ck12.org>

Colorín Colorado. (n.d.). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>

National Aeronautics and Space Administration (NASA) Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*. <https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

TeachEngineering. (n.d.). *Cooking with the sun—Creating a solar oven*. https://www.teachengineering.org/activities/view/duk_solaroven_tech_act

U.S. Department of Energy. (2017). *Energy literacy: Essential principles and fundamental concepts for energy education* (Version 5.0). https://www.energy.gov/sites/prod/files/2017/07/f35/Energy_Literacy.pdf

References

- CAST. (2018). *Universal design for learning guidelines version 2.2*. <https://udlguidelines.cast.org>
- CK-12 Foundation. (n.d.-b). *Solar energy (20.11)—CK-12 Earth science for middle school*. <https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/20.11/primary/lesson/solar-power-ms-es/>
- Colorín Colorado. (n.d.-a). *ELL classroom strategy library*. <https://www.colorincolorado.org/ell-strategy-library>
- Freire, P. (2018). *Pedagogy of the oppressed* (50th anniversary ed.). Bloomsbury Academic.
- Georgia Department of Education. (n.d.). *Science – Georgia standards of excellence*. <https://www.gadoe.org/learning/science/>
- International Society for Technology in Education. (n.d.). *ISTE standards: Students*. <https://iste.org/standards/students>
- Love, B. L. (2019). *We want to do more than survive: Abolitionist teaching and the pursuit of educational freedom*. Beacon Press.
- Muhammad, G. (2023). *Unearthing joy: A guide to culturally and historically responsive teaching and learning* (Foreword by Pharrell Williams). Scholastic.
- My NASA Data. (n.d.). *Earth's energy budget—Lesson plans*. <https://mynasadata.larc.nasa.gov/phenomenon/earth-energy-budget/lesson-plans>
- NASA Climate Kids. (n.d.). *What is the greenhouse effect?* <https://climatekids.nasa.gov/greenhouse-effect/>
- National Academies of Sciences, Engineering, and Medicine. (2017). *Seeing students learn science: Integrating assessment and instruction in the classroom*. National Academies Press. <https://doi.org/10.17226/23548>
- National Academies Press. (2017). *Energy literacy: Essential principles and fundamental concepts for energy education* (Version 5.0). U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2017/07/f35/Energy_Literacy.pdf
- National Oceanic and Atmospheric Administration. (n.d.). *The transfer of heat energy*. <https://www.noaa.gov/jetstream/atmosphere/transfer-of-heat-energy>
- National Renewable Energy Laboratory. (n.d.). *Education resources for students*. <https://www.nrel.gov/about/education-students-resources>
- National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. <https://doi.org/10.17226/13165>
- NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press. <https://doi.org/10.17226/18290>
- Palcik, J. (2021). *Science lab & prep area safety guidance resource*. Flinn Scientific. <https://www.flinnsci.com>

PhET Interactive Simulations. (n.d.). *Heat & thermodynamics simulations*.

<https://phet.colorado.edu/en/simulations/filter?subjects=heat-and-thermodynamics>

Science Buddies. (n.d.). *Investigate the greenhouse effect*. https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvSci_p047/environmental-science/what-is-the-greenhouse-effect

TeachEngineering. (n.d.-b). *Our sun and heat transfer basics: Heat it up!*.

https://www.teachengineering.org/activities/view/cub_solar_lesson02_activity1

United States Botanic Garden, National Center for Appropriate Technology, & City Blossoms. (2019). *Greenhouse manual: An introductory guide for educators*. <https://www.usbg.gov/greenhouse-manual>

Willard, T. (Ed.). (2014). *The NSTA quick-reference guide to the NGSS, K–12*. NSTA Press.