Quick start · Two session routes

Print the teacher guide and use the student selections listed on each session page. Keep the matching teacher keys and quick starts separate. The complete thermal energy classroom archive contains the six resources and the start guide. The optional cool-water investigation archive contains its own materials and forms. No student internet access is required.

Planning estimates. The six-session paper route may use continuation blocks, particularly for Revise a Claim When Evidence Changes and Choose, Test and Improve a Thermal Protector. The eight-session practical route includes three first comparisons and three redesign comparisons with fresh water. If the class period is 45 min, split at the specified continuation point; do not eliminate repeats or assign equipment homework.

Collect representative responses, not scores. Check prerequisites, support access, then choose an exact follow-up. Quick Check reuses Independent task.

Paper session 1 · Read measurements

Target / planning estimate

Read measurements; 35–45 min.

Print / prior evidence

Read Temperature Data Before Explaining It Teach-the-Lesson, student pp. 1–5; Read before comparing, questions 1–2, Read the whole record, questions 1–3, The same record as a graph, questions 1–2, Guided practice · Cooling, questions 1–3, Independent task · New readings, questions 1–3.

Read small tables and subtract; Bridge checks this.

Teacher demonstration

Trace one row: initial, final, time and direction, using the Model. Show equivalent graph representation without requiring plotting.

Learner work / collect

Guided practice, then independent task. Collect starting values, change, direction and observation.

Next decision / continuation

If values are reversed or mixed: Keep readings in one row, questions 1–2; if final and change are confused: A value is not a change, questions 1–3 before the next session.

Paper session 2 · Evaluate conditions

Target / planning estimate

Evaluate conditions; 35–45 min.

Print / prior evidence

Was It a Fair Comparison? Teach-the-Lesson, student pp. 1–4; Read before evaluating a comparison, questions 1–2, Two things changed, questions 1–3, Guided practice · Repair setup cards, questions 1–3, Independent task · Fresh critique, questions 1–3.

Evidence of headings and change from session 1; use Was It a Fair Comparison? prerequisite bridge if entering directly.

Teacher demonstration

Identify the intended comparison and relevant conditions for mass, start, time, cup, room and readout in the Model.

Learner work / collect

Critique the guided-practice record, repair the plan, then independent task. Collect named confounds and a matched recording plan.

Next decision / continuation

Subtraction does not fix a confound, questions 1–2 for confounds; Specify a usable plan, questions 1–3 for recording details before trial comparison.

Paper session 3 · Support a design choice

Target / planning estimate

Support a design choice; 36–44 min.

Print / prior evidence

Which Design Is Better Supported? Teach-the-Lesson, student pp. 1–4; Prerequisite mini-lesson · Read before comparing, questions 1–4; Teacher model · Which sleeve slowed warming?, questions 1–5; Guided practice · Check every trial, questions 1–3; Independent task · Choose from new results, questions 1–5.

Comparable conditions and temperature change; The prerequisite bridge supplies a check.

Teacher demonstration

Use the Model for a matched comparison and bounded claim; do not show independent task in the model.

Learner work / collect

Guided practice, then the unseen independent task. Collect comparisons across trials and one useful limit.

Next decision / continuation

In Which Design Is Better Supported?, use Use all results and limit the claim, questions 1–3 for selecting only favorable evidence or saying “always”; reserve the separate New short check · Apply the correction, question 4 until practice is complete. Use Compare the measurements, questions 1–2 when reading changes is difficult; use the separate reserved Fresh check, question 3 only after practice, if unseen. Use the unseen Later check · Reverse the direction, questions 1–3 later, rather than repeating the Quick Check.

Paper session 4 · Explain the pattern

Target / planning estimate

Explain the pattern; 36–45 min.

Print / prior evidence

Explain Why the Temperature Changed Teach-the-Lesson, student pp. 1–5; Observation, evidence, explanation, questions 1–2, Explain this record, questions 1–2; Model representation · Sample and surroundings, question 1, Guided practice · Explain a different record, questions 1–3, Independent task · Explain the record, questions 1–3.

Read changes and distinguish observations; Bridge checks the scientific connection.

Teacher demonstration

Model the 100 g cool-water sample warming from 12°C to 17°C in 15 minutes in 24°C surroundings. Explain net thermal-energy transfer from the warmer surroundings toward the cooler sample. Contrast the guided case: a sample cools from 37°C to 30°C in 21°C surroundings, with net transfer outward.

Learner work / collect

Guided cooling, then independent task; collect values, direction, idea and limit.

Next decision / continuation

Connect evidence to the explanation, questions 1–2; Fresh recheck · Connect a new record, question 1 if only readings are given; Trace energy transfer, questions 1–2; Fresh recheck · Trace a new case, question 1 for net direction, cold or stopping transfer; clarify wording first.

Paper session 5 · Revise a particular claim

Target / planning estimate

Revise a particular claim; 45–55 min.

Print / prior evidence

Revise a Claim When Evidence Changes Teach-the-Lesson, student pp. 1–8; Compare a claim with its support, questions 1–2, Initial evidence, question 1; New evidence, questions 1–2, Revision record · Model case, questions 1–7, Guided practice · Initial evidence, question 1; Guided practice · Additional evidence, questions 1–2, Independent task · Initial record, question 1; Independent task · New record, questions 1–2.

A bounded claim and a scientific connection. Prerequisite bridge names the claim, evidence and conditions.

Teacher demonstration

Use Initial model record for the original claim, then reveal New model evidence; complete the seven revision fields.

Learner work / collect

Reveal Initial practice record→New practice evidence and Initial independent record→New independent evidence after original responses. Collect the original claim, new conditions, decision, reason and next evidence.

Next decision / continuation

Initial claim and support, question 1; Keep the evidence, change the claim, question 1; Fresh recheck · Initial record, question 1; Fresh recheck · Additional record, question 1 for ignoring records; Initial conditions and claim, question 1; Compare conditions before revising, questions 1–2; Fresh recheck · Initial conditions, question 1; Fresh recheck · Changed surroundings, question 1 for comparability or assuming the newest wins. Extend to a second block if 55 min is needed.

Paper session 6 · Complete the paper design cycle

Target / planning estimate

Complete the paper design cycle; 55–70 min or two blocks.

Print / prior evidence

Choose, Test and Improve a Thermal Protector Teach-the-Design-Challenge, student pp. 1–5; Requirements and predictions, questions 1–2, Check the complete brief, questions 1–2, A decision needs a priority, questions 1–2, Independent challenge · Record a proposal first, questions 1–2; Independent challenge · Separate redesign evidence, questions 1–2.

Feasible criteria and constraints, and revision. The prerequisite bridge supplies a standalone bridge.

Teacher demonstration

In the Model, check all trials, budget and thickness, and state a priority; guide the practice tradeoffs.

Learner work / collect

Initial independent record: proposal and test; then a separate New independent evidence reassessment of fictional redesigns. Collect feasibility, hypothesis, test and revised claim.

Next decision / continuation

Meet every requirement, questions 1–2 then Fresh recheck · What if none qualifies?, question 1; A proposal needs a relevant test, questions 1–2 then Fresh recheck · Whole design or one feature?, question 1; Later check · Changed requirements, question 1; Later check · One new environment record, questions 1–2 if unseen. Break after guided practice for continuation, not homework.

Practical route session 1 · Read and compare quantities

Target: Read and compare quantities. Planning estimate: 35–45 min.

Print / prior evidence

Use the exact Read Temperature Data Before Explaining It print selections and tasks from Paper session 1; collect change and direction.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Prerequisite bridge, then Model → Guided practice → Independent task.

Next decision / continuation

Use first follow-up and second follow-up as needed; carry checked start and time reading into the next session.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 2 · Plan a comparable investigation

Target: Plan a comparable investigation. Planning estimate: 35–45 min.

Print / prior evidence

Use the exact Was It a Fair Comparison? print selections and tasks from Paper session 2; collect a matched plan.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Was It a Fair Comparison? Model → Guided practice → Independent task; emphasize physical conditions in relation to the question.

Next decision / continuation

Complete follow-up on confounds and the recording plan before planning apparatus.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 3 · Use representative trial evidence

Target: Use representative trial evidence. Planning estimate: 36–44 min.

Print / prior evidence

Use the exact Which Design Is Better Supported? print selections and tasks from Paper session 3; collect a bounded comparison.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Model→Guided practice→Independent task; distinguish time points from fresh trials.

Next decision / continuation

In Which Design Is Better Supported?, use Compare the measurements, questions 1–2 for practice with changes or direction. Use the separate reserved Fresh check, question 3 only after practice, if unseen. For a cherry-picked result or unlimited claim, use Use all results and limit the claim, questions 1–3, then the separate New short check · Apply the correction, question 4 if unseen. Save Later check · Reverse the direction, questions 1–3 for later.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 4 · Explain and revise

Target: Explain and revise. Planning estimate: 60–75 min, or two blocks.

Print / prior evidence

Use the prerequisite bridge, model and representation, guided cooling case and independent task in Explain Why the Temperature Changed (student pages 1–5). Then use the bridge and initial/additional guided-practice evidence in Revise the Claim When Results Change (student pages 1, 5–6). Match activity headings and question numbers to the separate guides. Check preceding evidence or the named bridge before proceeding, and check the investigation setup before handling equipment.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Explain net transfer, then retain a bounded claim when new comparable results remain consistent. Collect a scientific connection and a reason for revision.

Next decision / continuation

Pause after the explanation independent task if a continuation is needed. In Explain Why the Temperature Changed, use Connect evidence to the explanation, questions 1–2 for readings without explanation, then Fresh recheck · Connect a new record, question 1. For reversed direction, cold as a substance or stopped transfer, use Trace energy transfer, questions 1–2, then Fresh recheck · Trace a new case, question 1. In Revise the Claim When Results Change, use Initial claim and support, question 1, then Keep the evidence, change the claim, question 1 when contrary evidence is ignored; reserve Fresh recheck · Initial record and Fresh recheck · Additional record. Use Initial conditions and claim, question 1, then Compare conditions before revising, questions 1–2 when conditions are pooled or the newest record is automatically preferred; reserve Fresh recheck · Initial conditions and Fresh recheck · Changed surroundings. Reveal each additional record only after the initial response is retained. Guided revision practice is supported work, not independent evidence.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 5 · Design against requirements

Target: Design against requirements. Planning estimate: 55–70 min or two blocks.

Print / prior evidence

Use the exact Choose, Test and Improve a Thermal Protector print selections and tasks from Paper session 6; complete the full proposal→reveal cycle.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Check every requirement, choose a priority, propose a matched test and reassess fictional redesigns.

Next decision / continuation

first follow-up and second follow-up as needed; prepare the Cool-water investigation teacher operational card and instruments before the next session.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 6 · Assemble and run first comparison

Target: Assemble and run first comparison. Planning estimate: 65–80 min plus teacher preparation.

Print / prior evidence

Cool-water investigation: Prepare and Run the First Comparison. Use Design Brief questions 1–2, Assemble and Label question 1, Instruments and Trial Order questions 1–2, Instrument-check Record question 1, the setup and reading-log questions on each of three First Comparison trial sheets, and Compare the First Trials questions 1–3. Full student pages 1–9 and 13; supplied first-comparison record on page 15 for the fallback route. Teacher setup pages 1–6 and keys on pages 8–12.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

The teacher checks container, lid, probe, water and setup readiness; model recording with the fictional completed record, not invented student results. Learners assemble a prototype, run three fresh paired trials at 0/5/10 min, and retain starts, conditions and departures.

Next decision / continuation

Collect three complete records from the first phase and the construction version. If the period is 45 min, stop after trial 1, then drain, clean and store dry labeled sleeves; continue fresh trials 2 and 3 in the next block before redesign. Never make up readings.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 7 · Redesign and begin retest

Target: Redesign and begin retest. Planning estimate: 45–60 min plus continuation as needed.

Print / prior evidence

Cool-water investigation: Redesign and Retest. Compare the original sleeve with the declared redesign. Use Commit to a Redesign questions 1–2 (full student page 14), the setup and reading-log questions on each of three Retest trial sheets (pages 10–12), and Reassess the Redesign questions 1–2 (page 17). Use the supplied retest record on page 16 only for the fallback route. Teacher setup pages 2–6 and keys on pages 12–16.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Analyze all first records; state the prediction, modification and constraints. The teacher confirms safe assembly and a matched question. Assemble, record the version and perform the first fresh paired trial of the old reference and redesign.

Next decision / continuation

Collect the design log, prediction and first retest record. If the first phase is incomplete, continue it first; retain 3 fresh pairs per phase. Do not replace unknown results with fallback values.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.

Practical route session 8 · Finish retest and explain limits

Target: Finish retest and explain limits. Planning estimate: 50–65 min; add a continuation block if measurement or cleanup causes delays.

Print / prior evidence

Cool-water investigation: finish Retest trial sheets 2 and 3 (full student pages 11–12), then use Reassess the Redesign questions 1–2 and Evidence and Explanation questions 1–3 (pages 17–18). Teacher keys are on pages 15–17. Save the separate Later Reasoning Check, question 1 (page 19), for students who have not yet seen it.

Prerequisites: preceding collected evidence or the corresponding standalone kit bridge. The Cool-water investigation operational setup must be fully checked before handling.

Demonstration / learner work / collect

Run the remaining two fresh pairs (0/5/10 min), compare all retests with the identified reference, and account for drift, mismatch or missing data; use the supplied fallback if equipment is unavailable.

Next decision / continuation

Collect all raw records, a bounded result, revision and next test; clean up. Worse, negligible or variable outcomes are legitimate. Keep notes about actual physical work separate from the paper fallback.

No equipment homework or mandatory student internet access. Use the complete Cool-water investigation fallback for learners who do not handle equipment or when equipment is unsuitable; record that the fallback does not show construction or testing.