Teacher quick start · Explain Why the Temperature Changed

Target: connect temperature observations to a scientific explanation of net transfer, distinguish observations/models and state a limit. Prerequisites: °C/time/start/change, warming/cooling and sample/surroundings; The prerequisite bridge supplies all needed instruction. Intended for Grade 6 within the NGSS Grades 6–8 band; check local course placement. Paper and pencil only. Optional calculator, number line, pointing, projection, oral explanation or labeled diagram.

Print and teach

Teach the Lesson: Teach the Lesson (PDF), student pp 1–5 (Prerequisite bridge/Teacher model/Model representation/Guided practice/Independent task). Teacher pp 2–5. Use a Quick Check: Use a Quick Check (PDF), Independent task, student p 5; teacher p 5. The independent task is the same independent task in the lesson, not fresh afterward.

Reteach: Connect Evidence to the Explanation: Explain Why the Temperature Changed--Reteach Connect Evidence to the Explanation (PDF), First follow-up and fresh check, student pp 6–7; teacher p 6. Reteach: Trace Energy Transfer: Explain Why the Temperature Changed--Reteach Trace Energy Transfer (PDF), Second follow-up and fresh check, student pp 8–9; teacher p 7. Use a Later Check: Use a Later Check (PDF), Later check/Explanation check, student pp 10–11; teacher p 8. Each selection contains its own setup/data.

Sequence and response route

Planning estimates: Bridge 8 min → Model/Representation 10 min → Guided practice 8 min → Independent task 10 min, about 36–45 min; reteach 10–15 min; later 8–12 min. Model the representation, prompt guided practice, then collect the independent response without its key. Keep teacher files separate.

Repeats readings without connection → First follow-up and fresh check. Reversed arrow, cold-as-substance or stopped-transfer idea → Second follow-up and fresh check, after clarifying intended meaning. Correct arrow without data → First follow-up. Accept accurate connected prose, a labeled representation, or an oral explanation pointing to data. First ask the learner to point to the row, restate the question and explain aloud. Record response mode and support. An unclear or blank response is insufficient evidence of a science difficulty; clarify reading, language and access before choosing a reteach.

All data constructed. No apparatus, scoring or uploads. Use a still-unseen later check after the independent task.

Teach the prerequisite bridge

100 g water;23°C surroundings;10 min

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Sample	Start (°C)	After 10 min (°C)
H	13	17

Say: “H13°C at start is an observation. I select 13→17°C because our question asks whether it warmed: that is evidence. I add an explanation: the surroundings are warmer than H, so net thermal-energy transfer is toward the water. That scientific idea connects the evidence; it is not another thermometer reading. The sample is water; surroundings include cup/lid/support/room.”

Observation, evidence, explanation, question 1: Water H;23°C surroundings;13°C sample start,10 min,13→17°C =4°C warming. Surroundings include cup/lid/support/room, not only the air.

Observation, evidence, explanation, question 2: (a) observation; (b) evidence selected to support warming; (c) scientific idea explaining direction in this stated case. Evidence is selected observations, not a separate type of measurement. An explanation must connect(c) to 13→17°C, not merely name a law.

Readiness: ask for a point to start/final/unit/time and identification of the warmer part. If subtraction alone is difficult, use a number line/calculator. If observation versus explanation is unclear, sort the three statements aloud and ask what the idea adds. If direction remains reversed, teach Trace energy transfer before the independent task. Do not require the earlier resources; this bridge teaches needed ideas.

Complete Model

100 g water;24°C surroundings;one 15 min run

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Elapsed time (min)	Water (°C)
0	12
5	14
10	16
15	17

Think aloud: “12→17°C is 5°C warming. The incomplete answer accurately reports this but does not explain it. I identify the water as our sample and 24°C surroundings as warmer. Net thermal-energy transfer is toward cooler water; that is consistent with warming. I draw a boundary around water and an arrow inward. The arrow uses a scientific idea; the table did not measure it.”

Defensible model: “The water warmed from 12°C to 17°C in 15 minutes. In this passive setup,24°C surroundings are warmer, so net thermal-energy transfer is toward the water. This accounts for the rise; the record does not identify each pathway or document an actual experiment.”

Equivalent model description: outer region room/cup/lid/support 24°C; inner water 100 g,12→17°C; arrow surroundings→water labeled net thermal-energy transfer. The original representation is on Graph or model representation; these labels describe its full content.

Explain this record, question 1: All quoted values and 5°C warming describe supplied observations; they do not connect to the warmer surroundings and transfer direction.

Explain this record, question 2: Water rose 12→17°C over 15 min.24°C surroundings are warmer throughout. Net thermal-energy transfer is toward the cooler water, consistent with warming. This is a science-informed explanation of a constructed pattern; it does not prove a unique pathway, actual product performance or an instantaneous rate. Accept any scientifically adequate connection and specific limit.

Model representation · Sample and surroundings, question 1: Table observations: time/readings and their calculated 5°C rise. The representation adds a boundary and net-transfer arrow using a scientific model. The thermometer did not measure the arrow or the separate pathways; conduction alone is not established.

Draw only the net arrow; do not imply particles cross the boundary or that temperature measures total stored energy. Repeated time readings of this one sample are not independent trials.

Cooling practice and actual teaching moves

100 g water;21°C surroundings;one 15 min run

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Elapsed time (min)	Water (°C)
0	37
5	34
10	32
15	30

Ask: “Which two readings matter? Name the warmer part. Where should a net-transfer arrow start/end? How does that help explain the change?” If “cold entered,” ask the learner to point to warmer/cooler and trace the arrow; then refine wording. If “lower is better,” return to the question: explain the change, not select a design.

Guided practice · Explain a different record, question 1: 37→30°C from 0→15 min is 7°C cooling. Accept e.g.37°C at 0 min and 32°C at 10 min with a 5°C fall for that stated interval, or additional accurate readings. The full-interval answer is 7°C.

Guided practice · Explain a different record, question 2: Water is warmer than 21°C surroundings throughout; net thermal-energy transfer is from water toward surroundings, consistent with its falling temperature. Accept outward arrow with labels/readings or an oral account. Cold is not a transferred substance.

Guided practice · Explain a different record, question 3: We explain why temperature changed; there is no comparison design or performance criterion. Lower temperature alone does not establish a better sleeve. No ranking, unique mechanism, total-energy amount or real experiment is established.

Anticipated answer “37→30°C because it cooled”: accurate description, missing connection; request surrounding temperature and direction. “Energy leaves”: ask which sample, why that direction, and which readings support cooling. Accept a correct outward labeled arrow with data. If the idea is correct but writing is difficult, collect an oral response and note support.

Independent key and routing

fresh 80 g each;20°C surroundings;12 min;matched independent trials

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Trial ID	Start (°C)	After 12 min (°C)
I-1	31	27
I-2	31	26
I-3	31	27

Independent task · Explain the record, question 1: 31→27°C is 4°C cooling in I-1/I-3;31→26°C is 5°C cooling in I-2. All cool across 12 min. Use two or all three trials. Do not invent a cause for I-2's difference.

Independent task · Explain the record, question 2: Sample:80 g water; surroundings 20°C; water 31°C initially and 26–27°C finally, all warmer than surroundings. Net energy transfer is outward, consistent with cooling. Specific initial/final readings and the cooler surroundings must connect; naming transfer without connecting to data is incomplete.

Independent task · Explain the record, question 3: Accept unmeasured pathways, other intervals/conditions, unknown accuracy or invented data's lack of actual physical evidence, with a matching next step. Example: pathway contributions need measurements designed to separate them, not these endpoints. Observed (supplied): time/temperatures. Model: net arrow and scientific direction. No instantaneous rate or total-energy calculation required.

Look separately for selected evidence, sample/surroundings, scientifically consistent direction/connection and a meaningful limit. No rigid sentence count or CER boxes. Correct 4/5°C calculations alone do not show explanation. Ask "How does the surroundings' temperature help explain it?" before reteach.

If only readings appear, choose First follow-up and fresh check. If the arrow remains inward for this case or speaker insists cold is a transferred substance, choose Second follow-up and fresh check after clarification. A mismatch between a correct oral account and written response indicates an expression/access need. Do not use Quick Check as unseen after the lesson.

Connect evidence to the explanation

100 g water;26°C surroundings;one 10 min run

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Elapsed time (min)	Water (°C)
0	15
5	18
10	20

Think aloud: “Response 1 supplies 15→20°C but no reason. Response 2 has a scientific rule but no link to this case. I join them: water warms 5°C while 26°C surroundings are warmer; net transfer toward water accounts for the rise. I can use a data-labeled arrow, not a prescribed paragraph.” Ask learner to supply Connect evidence to the explanation, question 2, keeping the two incomplete responses visible.

Connect evidence to the explanation, question 1: Response 1 supplies readings but no scientific connection; response 2 supplies a general idea without identifying the specific warmer/cooler parts or evidence. Both can be improved; do not treat a correct generic idea as wholly wrong.

Connect evidence to the explanation, question 2: 15→20°C over 10 min gives 5°C warming;26°C surroundings warmer than water; net energy transfers toward water, consistent with rise. Thermometer record does not measure individual pathways. Accept a labeled arrow linked to readings without prose.

follow-up check ·fresh 90 g water;23°C surroundings;8 min

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Sample	Start (°C)	After 8 min (°C)
R	35	31

Fresh recheck · Connect a new record, question 1: 35→31°C over 8 min is 4°C cooling; water warmer than 23°C surroundings; net transfer outward. Accept a meaningful pathway/other-condition/constructed-data limit. This fresh cooling case checks the connection, not paragraph fluency.

Recheck A3 has not been modeled; withhold it until practice is complete. An adequate connection shows use on this task, not mastery. If evidence accurate but direction reversed, use Trace energy transfer. If arrow correct without values, prompt one specific reading and explain its relevance.

Trace energy transfer

matched 100 g;22°C surroundings;15 min

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Setup	Start (°C)	After 15 min (°C)
No sleeve	10	18
Sleeve V	10	14

Intervention: “Point to 10°C water and 22°C surroundings. Which is warmer? Show the net arrow.” Then trace V10→14°C. “It warmed, so in this passive case transfer did not stop. It warmed less than no sleeve, which is a different statement from cooling.” Ask the learner what “cold entered” means before labeling the idea. Use their arrow/data account to distinguish loose wording from a reversed model.

Trace energy transfer, question 1: Ask “Which part is warmer? Show where your arrow begins and ends. Do you mean the water changed temperature, or cold is a substance?”10→14°C shows V warmed 4°C; no sleeve warms 8°C. If speaker gives correct outward/inward direction and uses colloquial cold, refine language without automatically assigning conceptual reteach. A repeated reversed arrow or claim of no transfer despite warming indicates a conceptual issue.

Trace energy transfer, question 2: V10→14°C warms 4°C;22°C surroundings warmer. Net transfer inward; V limits warming relative to no sleeve 10→18°C, but does not lower its start or stop transfer. Equal water masses and phase allow smaller rise to be consistent with less net energy entering over this interval. No unique pathway or proven material property.

comparison check ·fresh 100 g sleeved water;21°C surroundings;10 min

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Sample	Start (°C)	After 10 min (°C)
Sleeved W	33	29

Fresh recheck · Trace a new case, question 1: 33→29°C is 4°C cooling;21°C surroundings cooler; net transfer outward. Sleeve did not make cold or stop the net transfer indicated by cooling in this passive case. No unsleeved comparator, so no quantified sleeve effect; any specific-condition or mechanism limit acceptable.

Fresh recheck · Trace a new case, question 1 reverses direction; do not draw its arrow first. If correct after support, record that support. Unknown pathway, no control and constructed data remain useful limits.

Later key and interpretation

60 g water;19°C surroundings;one 12 min run

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Elapsed time (min)	Liquid water (°C)
0	9
6	12
12	14

Later check · A changed setting, question 1: 9→14°C over 12 min is 5°C warming (12°C at 6 min also valid evidence).19°C surroundings warmer; net transfer inward. Chamber context changes, science connection persists. No pathway partition, instantaneous rate or actual experiment follows.

idealized uniform 22°C, not measured equilibrium

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Idealized case	Water (°C)	All surroundings (°C)
Uniform temperatures throughout	22	22

Later check · Idealized equal temperatures, question 1: Given uniform equal temperatures and the exclusions, no net thermal-energy transfer driven by a temperature difference. Particles of 22°C liquid water continue moving; microscopic exchange can occur with no net transfer. Equal temperature does not mean no particle motion or equal total energy in unlike amounts/types of matter.

Later check · Idealized equal temperatures, question 2: One unchanged reading does not prove equilibrium. Need surrounding and sample temperatures (including uniformity), time evidence, measurement accuracy/resolution and absence of other inputs/outputs or balancing processes. Accept a coherent subset with explanation of why. A reading may hide a small change or reflect balanced transfers.

A successful response shows explanation in this changed setting and distinction between no net transfer and particle motion. It does not prove durable mastery, equal difficulty with the independent task, actual investigation skill or instrument competence. Later check and explanation must remain unseen until later. Clarify access/meaning before choosing Connect Evidence to the Explanation or B.

Science, sources and partial standards

A temperature reading is not total energy. Type, state and amount of matter also affect total energy. For these passive, single-phase cases, net thermal-energy transfer is from warmer parts toward cooler parts. An arrow represents that net transfer, not a substance called cold or an individual particle path. Temperature readings alone do not isolate conduction, convection or radiation, calculate total transferred energy, or show an instantaneous transfer rate. Limiting warming is not cooling; limiting transfer is not stopping it.

Explain Why the Temperature Changed P/M/Guided practice and independent task/A/B/T connect evidence with a net-transfer model: selected PS3.B ideas from MS-PS3-3, and the evidence/explanation and temperature distinctions in MS-PS3-4. These tasks neither construct/test a device nor conduct an investigation or cover the whole expectations. The explanation check adds a conceptual equilibrium distinction, not a complete standards assessment.

OpenStax College Physics 2 e 13.1 and 13.4 support equilibrium/no net transfer and continued thermal particle motion at nonzero temperature: https://openstax.org/books/college-physics-2e/pages/13-1-temperature and https://openstax.org/books/college-physics-2e/pages/13-4-kinetic-theory-atomic-and-molecular-explanation-of-pressure-and-temperature. Teacher background only; no formulas or total-energy calculations required.

Official sources checked 2026-09-29: NGSS MS-PS3-3 (https://www.nextgenscience.org/pe/ms-ps3-3-energy) and MS-PS3-4 (https://www.nextgenscience.org/pe/ms-ps3-4-energy); NSTA revision connection (https://my.nsta.org/ngss/NSforSEP.aspx?id=3). These support specific ideas, not validation or complete standards coverage. All text/data/representations are original; external sources are paraphrased and linked, not reproduced. Classroom copying/adaptation follows https://mentorteaching.com/terms-of-use/.

No practical procedure, real product inference, instrument accuracy or measured learning outcome is supplied. All timings are planning estimates.

Fictional teaching response — sound for the named task

Named task: Independent task: Explain the record, questions 1–3

Fictional response — sound for the named task: “The three 31°C samples end at 27, 26 and 27°C after 12 minutes: falls of 4, 5 and 4°C. The sample is initially warmer than the 20°C surroundings. In the stated model, net thermal-energy transfer is from the warmer sample toward the cooler surroundings, accounting for cooling. The readings are observations; that transfer account is an explanation under the supplied conditions. The records do not isolate a transfer pathway or show what every cup would do. As a hypothetical next comparison, I would compare the original covered-cup design with the same design plus one dry paper sleeve around its side wall, using three fresh paired 80 g samples starting at 31°C in 20°C surroundings for 12 minutes, with the same lids and reading procedure. I would retain starts, endpoints and anomalies without predicting a measured result. That would address this specified sleeve change, not every design.”

Visible evidence: Accurate pattern/changes connected to sample, surroundings and net-transfer direction, with a distinction and useful bounded next test.

Not established: A measured pathway, energy amount or general classroom investigation competence.

Clarify: Ask which part of the response comes directly from readings and which uses the model assumptions.

Next teaching/evidence: Use the separate Later assessment after another learning opportunity. The Quick Check repeats this independent task and is not new evidence.

This response is invented for teacher interpretation. Accept defensible alternatives. Record access, prior exposure and the actual response; do not assign an ability label or claim mastery from this example.

Later assessment

Fictional teaching response — partially developed

Named task: Independent task: Explain the record, questions 1–3

Fictional response — partially developed: “It went from 31°C to 27°C or 26°C. It cooled.”

Visible evidence: Accurate starting/final values and temperature direction.

Not established: Two explicit changes, a net-transfer explanation or a meaningful limit.

Clarify: Ask what is warmer, identify the surroundings and connect the readings to a direction of net transfer.

Next teaching/evidence: Use Connect evidence to the explanation, then the separate Fresh recheck of the connection. Keep the check unseen during response teaching.

This response is invented for teacher interpretation. Accept defensible alternatives. Record access, prior exposure and the actual response; do not assign an ability label or claim mastery from this example.

Connect evidence to the explanation

Fresh recheck of the connection

Reserve: Later assessment

Fictional teaching response — plausible error

Named task: Independent task: Explain the record, questions 1–3

Fictional response — plausible error: “Cold moved from the room into the water, making it cool.”

Visible evidence: The response associates the cooler surroundings with the observed cooling.

Not established: The supplied energy-transfer explanation: cold is not a transferred substance in this model; net thermal energy transfers outward from the warmer sample.

Clarify: Ask the learner to label sample/surroundings and warmer/cooler before drawing one net-transfer arrow.

Next teaching/evidence: Use Trace energy transfer, questions 1–2, then the separate Fresh recheck of transfer. Do not use the answered independent/Quick Check as fresh evidence.

This response is invented for teacher interpretation. Accept defensible alternatives. Record access, prior exposure and the actual response; do not assign an ability label or claim mastery from this example.

Trace energy transfer

Fresh recheck of transfer

Reserve: Later assessment