

Substitute Guide: Thermal Energy at School

Grade: 7 **Subject:** Science **Time:** ~45 min core + ~15 min extension Science

Learning goal (plain language)

Students learn the three ways heat (thermal energy) moves — **conduction** (touch), **convection** (moving air or liquid), and **radiation** (rays, like sunlight) — and that **temperature reflects how fast the particles are moving**. They practice by reading a diagram and a data table about a school building, then write a short evidence-based explanation. **You do not need a science background to run this.** Everything students need is printed in their packet.

Standards alignment

Framework: 19 TAC §112.27 (Grade 7 Science). Knowledge & skills **7.8** — thermal energy flowing into and out of systems.

- **Primary** — **7.8A:** methods of thermal energy transfer (conduction, convection, radiation).
- **Primary** — **7.8C:** the relationship between temperature and the kinetic energy of particles.

Provisional — pending educator verification against the current official TAC source.

(Standards are paraphrased here, not quoted. Please confirm codes and wording against your official source.)

Setup Before class (5 min)

- Count and hand out one **student packet** per student.
- Confirm each student has a **pencil**. No calculators, computers, or lab items are needed.
- Write the date on the board and remind students to fill in the name line.
- Keep the **answer key** with you — it is a separate file and is **not** in the student packet.

Materials What's needed

- Printed student packet (4–6 pages) per student.
- Pencil per student.
- This guide and the separate answer key (teacher only).
- No technology, no calculator, no lab equipment, no safety hazards.

Timing Suggested pacing (~45–60 min)

Segment	Time	What students do
Start — Notice & Wonder	5 min	Q1–Q2 warm-up
Build — Read the science	5–10 min	Read passage, word bank, diagram; Q3
Apply — Use the data	20–25 min	Table 1; Q4–Q7
Explain — CER	5–10 min	Q8 claim/evidence/reasoning

Segment	Time	What students do
Close — ACE	5 min	Articulate / Connect / Extend
Continue — early finishers optional ~15 min "Cool bench" design		

Script Read aloud to start

"Today's assignment is a paper science investigation called *Thermal Energy at School*. You will work by yourself with just a pencil — no computers or calculators. First read the short passage and study the diagram and the data table. Then answer the questions in order; if one is tricky, skip it and come back. Write in complete sentences where it asks you to explain. You may quietly read the passage aloud to yourself. Put your name, class period, and date at the top now. You have about 45 minutes; raise your hand if you need help understanding a word."

Support When students ask for help

- **You may read any part aloud** to a student or the class.
- If they are stuck on a mode, point them to the **Word Bank** and **Figure 1** — the answers to "which mode" are visible there.
- Encourage the printed **sentence stems** for the CER (Q8) and ACE sections.
- Do **not** give answers; prompt with "What does the data show?" or "Which picture matches this?"
- It is fine if a student cannot finish the optional early-finisher task.

Access Accommodations & language support

- **Read-aloud** of any passage or question is allowed for all students.
- Point students to the **sentence stems** and the **Word Bank** (definitions provided).
- Extended time is fine; the core can stop after Q8 if time runs short.
- Students may answer in phrases if writing full sentences is a barrier, as long as the idea is clear.
- The packet is grayscale-safe — it prints and reads clearly in black and white.

Tools Allowed & not allowed

Allowed: pencil, the printed packet, quiet self-read-aloud. **Not needed / not allowed:** calculator (no math required), phones, computers, lab materials.

Collect at the end: Collect every packet, whether finished or not, with names on them. Stack them for the teacher. Note on a sticky how far most students got and any questions that caused confusion.

Answer key: The **answer key is a separate file** (answerkey.html) and is for the teacher only. Please do not hand it to students.

Teacher follow-up (for the returning teacher)

Watch for the common misconception that "cold flows in" — thermal energy actually *leaves* the warmer object. A quick next-day discussion sorting a few real school examples into conduction / convection / radiation, plus reviewing the observation-vs- inference item (Q4), would reinforce this well. The CER (Q8) responses show who can cite data as evidence.

Thermal Energy at School

Grade: 7 **Subject:** Science **Time:** ~45 min core + ~15 min extension **Work mode:** Independent · pencil only
Science

Start Here

This is a **paper investigation**. You will read a short passage, study a diagram and a data table, and answer questions using a pencil. You do **not** need a computer, a calculator, or any lab materials. Work by yourself and do your best thinking. Write in complete sentences where you are asked to explain. If a question is hard, skip it, keep going, and come back. Reading the passage aloud quietly to yourself is allowed and encouraged.

Start Notice & Wonder 5 min

Think about ordinary warming and cooling you feel during a normal school day.

1 You touch a metal locker handle and a wooden pencil that have been sitting in the same room all morning. The metal feels colder even though a thermometer says they are the same temperature. Write **one thing you notice** and **one thing you wonder** about this.

2 Name **two places at school** where something obviously gets warmer or cooler during the day (for example, a spot by a window). For each one, say whether it warms up or cools down.

Build Read the Science 5–10 min

How thermal energy moves

Thermal energy is the energy of the tiny moving particles inside matter. When particles move faster, the material is warmer; when they move slower, it is cooler. So **temperature is a measure of the average kinetic energy (motion energy) of the particles**. Heating something makes its particles jiggle and move faster.

Thermal energy always moves from **warmer** to **cooler** until both reach the same temperature. That balanced, no-change state is called **thermal equilibrium**. There are three ways the energy travels:

- **Conduction** — energy passes through direct contact, particle to particle. A metal spoon warming in hot soup is conduction. Metals conduct quickly; wood and plastic conduct slowly, which is why they feel warmer to the touch.
- **Convection** — energy is carried by a moving fluid (a liquid or a gas). Warm air is less dense, so it rises; cooler air sinks to take its place, making a loop called a convection current.
- **Radiation** — energy travels as invisible rays that can cross empty space, needing no particles at all. Sunlight warming a desk is radiation.

Remember: nothing "cold" ever flows *in*. Something feels cold because thermal energy is flowing *out* of your hand into it.

Word Bank

- thermal energy
 - the total energy of the moving particles in matter.
- conduction
 - transfer of thermal energy through direct contact.
- convection
 - transfer of thermal energy by a moving liquid or gas.
- radiation
 - transfer of thermal energy as rays that can cross empty space.
- thermal equilibrium
 - when two things reach the same temperature and energy stops flowing net.

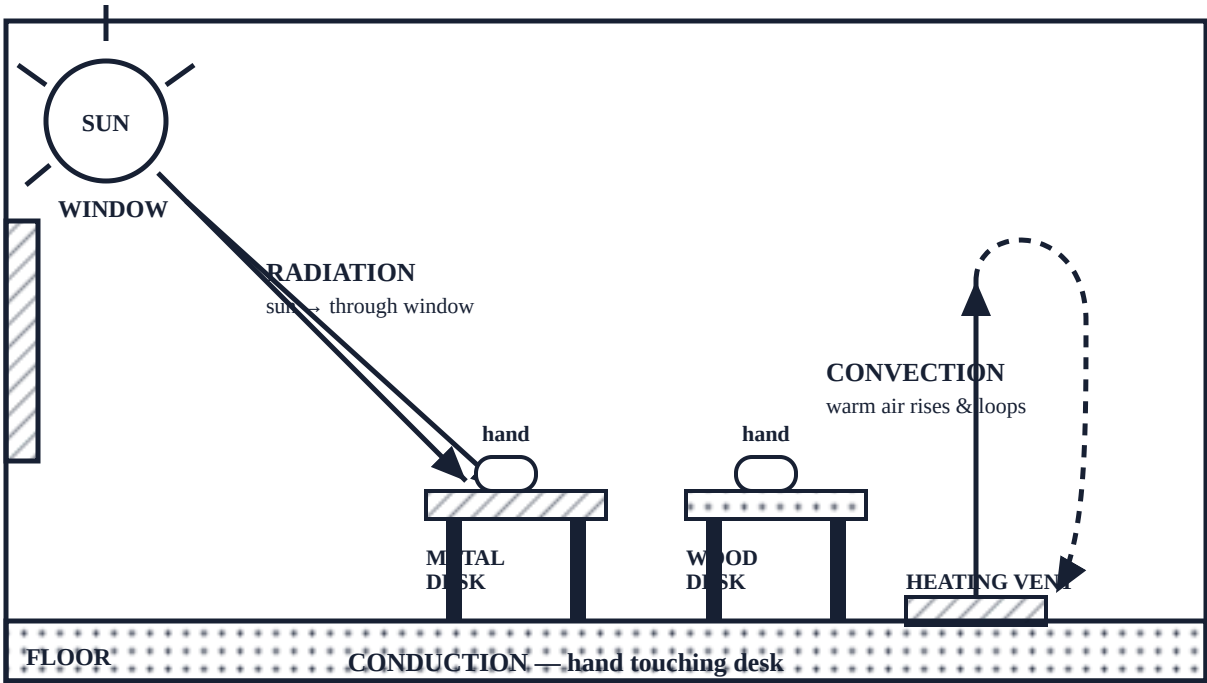


Figure 1. A sunny classroom in cross-section. Radiation from the sun passes through the window; a convection current loops up from the heating vent; conduction happens where a hand touches the metal desk and the wood desk. Fills are patterns (hatching, dots), not colors, so the figure reads clearly in grayscale.

3In the diagram, which transfer mode does **not** need any particles to travel? Name it and give the one example shown for it.

Apply Use the Data 20–25 min

A science club measured the temperature of surfaces and air around the building at the same time on a sunny afternoon. Study Table 1, then answer.

Table 1. Surface and air temperatures at 2:00 p.m. on a clear day (original class data).

Location / material	Temperature (°C)	In sun or shade?
Metal handrail (outside stairs)	48	Sun
Sunlit concrete sidewalk	44	Sun
Shaded concrete sidewalk	29	Shade

Location / material	Temperature (°C) In sun or shade?	
Wooden bench (outside)	34	Sun
Classroom air (near window)	27	Indoors
Classroom air (far corner)	24	Indoors

4Observation vs. inference. Read each statement. Write **O** if it is an observation (something directly measured or seen) or **I** if it is an inference (a conclusion you reason out).

- ____ a) The metal handrail was 48 °C.
 ____ b) The handrail felt too hot to grip because the sun heated it by radiation.
 ____ c) The far corner of the room was 24 °C.
 ____ d) The far corner is cooler because it is farther from the sunny window.

5Look at the two concrete readings. The same material is 44 °C in the sun and 29 °C in the shade. In one sentence, explain what caused the difference using a transfer mode from the Word Bank.

6Classify the transfer. For the scenario below, choose the ONE mode that best fits.

6a. A student sets a cold soda can on the sunny metal handrail; the can warms where it touches the metal.

- Conduction
- Convection
- Radiation

6b. A ceiling fan pushes warm air near the ceiling back down across the room.

- Conduction
- Convection
- Radiation

6c. Sunlight streams through the window and warms a dark backpack on the floor.

- Conduction
- Convection
- Radiation

7Redesign reasoning (multi-step). The classroom by the window gets uncomfortably hot on sunny afternoons. Using Table 1 and the diagram, choose ONE change from the list below and explain, in 2–3 sentences, **how it reduces unwanted heat transfer** and **which mode it targets**. Options: (i) light-colored blinds on the window, (ii) a fan to keep air moving, (iii) moving desks to the far corner.

Explain Claim–Evidence–Reasoning 5–10 min

Question 8. Which design choice would **most reduce heat transfer into a hot classroom**? Write a claim and support it with **two pieces of evidence** from Table 1 or the diagram, then explain your reasoning.

Sentence stems you may use: "The best choice is... because..." · "One piece of evidence is... (from Table 1 / the diagram)." · "A second piece of evidence is..." · "This works because thermal energy moves by... and..."

Claim

Evidence (two pieces)

Reasoning

Close ACE Wrap-Up 5 min

Articulate

Explain **one** transfer mode (conduction, convection, or radiation) in your own words, as if teaching a friend.

Connect

Point to one row of Table 1 or one part of the diagram that shows that mode. Name it.

Extend

Give a **new** example of that mode from somewhere *outside* of school.

Continue Early Finisher optional • ~15 min

If you finish early (no new materials needed):

Design a "cool bench." On the back of this page, sketch an outdoor bench that stays cooler in the sun than the 34 °C wooden bench in Table 1. Label at least **two features** and, for each, name the transfer mode it fights (conduction, convection, or radiation). Then **predict** a temperature for your bench and explain why it would be lower.

Turn in: Hand in this whole packet with your name, class period, and date filled in. Make sure questions 1–8 and the ACE box are answered. The early-finisher sketch is optional but turn it in too if you did it.

G07_SCI_ThermalEnergy_01 — Thermal Energy at School Student Packet



TEACHER ANSWER KEY FOLLOWS

Do not copy the pages after this divider for students.

Answer Key: Thermal Energy at School

Grade: 7 **Subject:** Science **For teacher use only** Science

How to use this key

Answers are grouped by section and question number. Many items are open-ended; accept any response that shows correct reasoning even if the wording differs. Notes flag where more than one answer is defensible and list common misconceptions to watch for. Estimated grading time: ~5–7 min per packet.

Start Notice & Wonder grade for effort · ~2 min

1 Metal vs. wood at the same temperature.

Full credit for any reasonable notice + wonder. **Ideal:** Notice — "the metal feels colder than the wood." Wonder — "why do they feel different if the thermometer reads the same?" Accept any on-topic wonder. *Science note (not required from students):* metal conducts thermal energy away from the hand faster, so it feels colder even at equal temperature.

2 Two places at school that warm or cool.

Accept any two real locations with a direction. Examples: a desk by a sunny window (warms), a shaded hallway (cooler), the cafeteria after cooking (warms), a stairwell in the morning (cool). More than one answer is defensible.

Build Read the Science ~1 min

3 Which mode needs no particles + the example shown.

Radiation. Example from the diagram: the sun's rays passing through the window (sun → through window). This is the only mode that can cross empty space.

Apply Use the Data ~2 min

4 Observation (O) vs. Inference (I).

- a) **O** — a directly measured value (48 °C).
- b) **I** — it explains a cause ("because the sun heated it by radiation").
- c) **O** — a directly measured value (24 °C).
- d) **I** — a reasoned conclusion about *why* it is cooler.

Observation = measured/seen directly; inference = a conclusion reasoned from evidence.

5 Sunlit (44 °C) vs. shaded (29 °C) concrete.

The sunlit concrete absorbed **radiation** from the sun, raising its temperature; the shaded concrete received little direct sunlight. Accept any sentence naming radiation (sunlight) as the cause of the ~15 °C difference. Reject "conduction" as the primary cause here.

6 Classify each transfer.

6a — A (Conduction). The can warms by direct contact with the metal rail.

6b — B (Convection). A fan moves warm air (a gas) around the room.

6c — C (Radiation). Sunlight (rays) warms the backpack.

7 Redesign reasoning (worked example).

Award full credit if the student names a valid mode *and* explains the mechanism. Worked examples:

- **(i) Light-colored blinds:** targets **radiation**. Blinds block/reflect incoming sunlight before it enters, so less radiant energy is absorbed inside. (Strongest choice — see Q8.)
- **(ii) Fan:** targets **convection**. Moving air mixes hot air away from students and speeds cooling; it does not stop energy from entering, so it helps less than blinds.
- **(iii) Move desks to the far corner:** uses the data (far corner air = 24 °C vs. near-window 27 °C). Reasonable, but it relocates students rather than reducing the heat entering — a weaker "fix."

Any of the three earns credit if the mode + mechanism are correct. Best-reasoned answer is (i).

Explain CER (Q8) ~1–2 min

8 Which choice most reduces heat transfer into a hot classroom?

Model answer. Claim: Light-colored blinds on the window would most reduce heat transfer into the classroom.

Evidence: (1) In Table 1, sunlit surfaces were far hotter than shaded ones (sunlit concrete 44 °C vs. shaded 29 °C), showing sunlight adds a lot of energy. (2) In Figure 1, the sun's radiation enters through the window — the main path of energy into the room. **Reasoning:** Because the biggest energy input is **radiation** through the window, blocking it at the window stops the energy before it enters, unlike a fan (which only moves already-warmed air by convection).

Defensible alternates: A student may claim the fan is best if they argue convection removes built-up heat and cite Table 1's air readings; accept with sound reasoning, but the blinds argument is stronger because it addresses the source.

CER scoring rubric (3 points)

Score	Claim	Evidence	Reasoning
3	Clear, correct choice stated.	Two accurate, relevant pieces from Table 1 and/or the diagram.	Correctly links evidence to a transfer mode and explains why it reduces heat.
2	Choice stated, mostly clear.	One solid piece, or two with a minor error.	Some correct linkage but incomplete or a small misconception.
1	Vague or partly correct choice.	Evidence weak, off-topic, or not from the sources.	Little or flawed reasoning; mode not correctly named.
0	No/incorrect claim.	No evidence.	No reasoning.

Close ACE ~1 min

ACE Articulate / Connect / Extend.

Articulate: accept any accurate plain-language definition of one mode (e.g., "conduction is heat moving through touch").

Connect: the cited row/part must actually match the chosen mode (e.g., metal handrail 48 °C → conduction/radiation; heating vent → convection; sun through window → radiation).

Extend: any correct new, out-of-school example (e.g., conduction — a spoon in soup; convection — boiling water; radiation — a campfire warming your face). More than one answer is defensible.

Watch Common misconceptions

- **"Cold flows in."** Cold is not a substance. Thermal *energy* flows out of the warmer object; there is no "coldness" moving in.
- **"Heat is a material/fluid inside things."** Heat is energy transferring, not stuff stored; "thermal energy" is the particle motion energy.
- **Metal is "colder" than wood.** At the same temperature they are equal; metal only *feels* colder because it conducts energy from the hand faster (Q1).
- **Confusing convection with radiation.** If a fluid (air/water) carries the energy, it's convection; if rays cross a gap, it's radiation.
- **Observation vs. inference (Q4).** Students often mark a reasoned cause as an "observation." Any "because..." statement is usually an inference.

Teacher follow-up based on likely errors

If many students miss Q4b/Q4d, do a 5-minute sort of statements into "measured" vs. "concluded." If Q6 or Q3 reveal convection/radiation confusion, re-anchor with Figure 1 (rays vs. moving air). If CER (Q8) evidence is thin, model citing a specific Table 1 row aloud. The "cold flows in" misconception is the highest-value item to address next class.

G07_SCI_ThermalEnergy_01 — Thermal Energy at School Teacher Answer Key