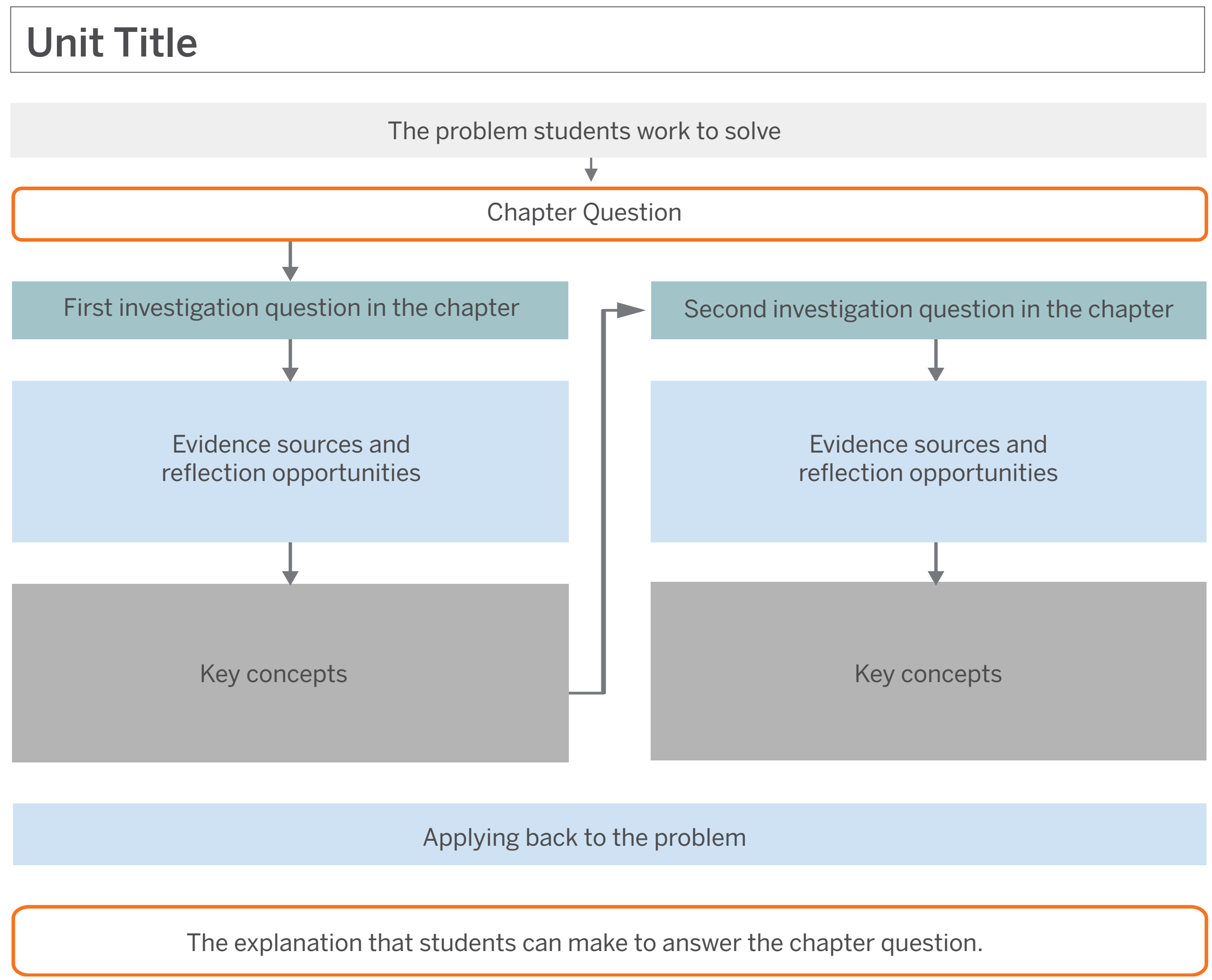
Thermal Energy Coherence Flowchart

The storyline of the unit

In each Amplify Science unit, students figure out a phenomenon by asking questions, gathering evidence, and coming up with an explanation of how the phenomenon works. The Coherence Flowchart visually represents the storyline of the unit, showing the coherent flow of questions, evidence, and ideas that support students as they build complex explanations of the unit's anchor phenomenon. The Coherence Flowchart on the following pages (one chapter per page) can be used to see the connections between the questions that drive students' experiences, the evidence they gather, the ideas they figure out, and the new questions that those ideas generate. The diagram to the right explains the structure of a chapter in the Coherence Flowchart.

Note: The Coherence Flowchart is a tool for teachers and is not meant to be distributed to students.

Typical structure of one chapter in a Coherence Flowchart



Instruction is framed by questions about the unit's anchor phenomenon and the related problem students are solving. Chapter Questions then guide students in figuring out the phenomenon, piece by piece. Within each chapter, Investigation Questions focus students on a manageable piece of content that will help them figure out the Chapter Question. Each question motivates activities, and each activity provides specific evidence related to the Investigation Question. Students synthesize the understanding constructed over multiple activities, and this understanding is formalized through key concepts. Often a key concept leads students to an additional Investigation Question students need to pursue to answer the Chapter Question. At the end of the chapter, students' new understanding is applied back to the unit's anchor phenomenon and leads students to a new Chapter Question or a final explanation.

AmplifyScience

Thermal Energy: Using Water to Heat a School

Problem students work to solve	Which heating system will best heat Riverdale School?
Chapter 1 Question	What is happening when the air in the school gets warmer?
Investigation Question	How is something different when it is warmer or cooler? (1.2-1.4)
Evidence sources and reflection opportunities	• Observe how food coloring spreads in hot and cold water (1.2) • Discuss how something is different when it is hot and when it is cold (1.2) • Use the Sim to compare hot and cold water at the molecular scale (1.3) • Identify a molecular model that shows the difference between hot and cold water (1.3)
Key concepts	• Things are made of molecules (or other types of atom groups). (1.3) • When a thing gets hotter, its molecules are moving faster. (1.3) • When a thing gets colder, its molecules are moving slower. (1.3) • Temperature is a measure of the average speed of the molecules of a thing. (1.4)
Application of key concepts to problem	• Use the paper Modeling Tool to show the difference between warmer and cooler air inside Riverdale School (1.4)
Explanation that students can make to answer the Chapter 1 Question	If the heating systems make the school's air warmer, it is because they increase the average speed of the molecules of the school's air. Things are made of molecules (or other types of atom groups). When a thing gets hotter, its molecules are moving faster. When a thing gets colder, its molecules are moving slower. Temperature is a measure of the average speed of the molecules of a thing.

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Problem students work to solve

Which heating system will best heat Riverdale School?

Chapter 2 Question

What causes the air molecules inside the school to speed up?

Investigation Questions

Why do molecules change speed? (2.1-2.3)

Why does the transfer of energy between two things stop? (2.4-2.7)

Evidence sources and reflection opportunities

- Use the Sim to visualize kinetic energy (2.1)
- Read “How Air Conditioners Make Cities Hotter” (2.2)
- Use the Sim to investigate two claims that answer the Investigation Question (2.3)
- Revisit “How Air Conditioners Make Cities Hotter” (2.3)

- Investigate energy transfer in the Sim (2.4)
- Use the Energy Cube Model to show energy transfer between objects (2.4)
- Use unit vocabulary to answer the Investigation Question (2.5)

Key concepts

- Revised: When a thing gets hotter, its molecules are moving faster and have more kinetic energy. (2.1)
- Revised:When a thing gets colder, its molecules are moving slower and have less kinetic energy. (2.1)
- Revised:Temperature is a measure of the average kinetic energy of the molecules of a thing. (2.1)
- When two things are in contact, their molecules collide, and kinetic energy transfers from the faster-moving molecules to the slower-moving molecules. (2.3)
- Energy isn’t created or destroyed. Therefore, as energy transfers, it increases in one part of the system as it decreases in another part of the system. (2.3)

- The molecules of a system will transfer energy until the system reaches a stable state known as equilibrium, in which all of the molecules are moving at about the same speed. (2.5)

Application of key concepts to problem

- Use the paper Modeling Tool to show how the groundwater system could heat the air inside Riverdale School (2.5)
- Discuss to compare the two heating systems for Riverdale School (2.5)

Explanation that students can make to answer the Chapter 2 Question

The air molecules inside the school will speed up if energy is transferred to them. When a thing gets hotter, its molecules are moving faster and have more kinetic energy. When a thing gets colder, its molecules are moving slower and have less kinetic energy. When two things are in contact, their molecules collide, and kinetic energy transfers from the faster moving molecules to the slower moving molecules.

Thermal Energy: Using Water to Heat a School

Problem students work to solve

Which heating system will best heat Riverdale School?

Chapter 3 Question

Which heating system will warm the air in the school more?

Investigation Questions

What determines how much total kinetic energy something has? (3.1-3.2)

What determines how much something will change temperature? (3.2-3.3)

Evidence sources and reflection opportunities

- Read "Thermal Energy Is NOT Temperature" (3.1)
- Compare the kinetic energy and thermal energy of a bathtub and a teacup of water (3.1-3.2)
- Revisit "Thermal Energy Is NOT Temperature" (3.2)

- Use the Energy Cube Model to show how samples made of different numbers of molecules reach equilibrium temperature (3.2)
- Compare the equilibrium temperatures of two systems of hot and cold water--one with more hot water and one with less (3.3)
- Use the Sim to model the two different systems (3.3)

Key concepts

- For things at the same temperature, the thing with more molecules has more total kinetic energy (thermal energy) than the thing with fewer molecules. (3.2)
- At equilibrium, the average kinetic energy (temperature) of the molecules in the system is the total kinetic energy (thermal energy) evenly divided by the number of molecules in the system. (3.2)

- When a thing gains or loses energy, the energy gained or lost is divided among all the molecules of the thing. (3.2)
- Revised: Energy isn't created or destroyed. Therefore, as energy transfers, it increases in one part of the system as it decreases in another part of the system. The total energy of a system doesn't change. (3.3)

Application of key concepts to problem

- Use the Sim to evaluate the two heating system proposals (3.3)
- Write an argument about the groundwater heating system (3.4)

Explanation that students can make to answer the Chapter 3 Question

The groundwater system will heat the school more because it uses so much more water than the other system, even though its water is not as warm as in the other system. For things at the same temperature, the thing with more molecules has more total kinetic energy (thermal energy) than the thing with fewer molecules. When a thing gains or loses energy, the energy gained or lost is divided among all the molecules of the thing.

Thermal Energy: Using Water to Heat a School

Problem students work to solve and the Chapter 4 Question

Why wasn't the water pasteurized?

Application of key concepts to new problem

- Analyze and sort evidence based on claims (4.1)
- Participate in the Science Seminar (4.2)
- Use the Reasoning Tool to connect the evidence to the claims (4.3)
- Write an argument to support a claim (4.3)

Explanation that students can make to answer the Chapter 4 Question

One possible explanation students can make:

Even if you follow the instructions, the kits from the Pasteurize Our Water organization will not heat the water above the correct temperature for pasteurization (65 degrees Celsius).

My evidence is that while using the cube to heat water works for water that starts at 18 degrees, 44% of people on Louis Island either used water from Lake Bogo or from an unknown water source. Lake Bogo is colder than 18 degrees and the unknown water sources may have been colder than 18 degrees, too. This matters because it takes more energy to heat colder water to above 65 degrees, and with these instructions, the cubes did not have enough energy to transfer to the water to cause it to reach 65 degrees. When a woman used water from Lake Bogo and followed the instructions, she got sick. Because the water was colder, the cube needed to transfer more kinetic energy, but the cube didn't have enough kinetic energy to transfer. Since the kit did not specify what the starting temperature of the water should be, the people who used colder water could have used the pasteurization kits correctly and still have gotten sick because their water did not reach 65 degrees. Based on this evidence, it seems that even if the kits are used correctly, they do not always heat water above 65 degrees.