

LESSON TITLE: IN-FLOOR RADIANT HEATING (PART 1)

TOTAL TIME: TWO 60-MINUTE PERIODS

BRIEF DESCRIPTION

In the first part of this *The House That STEM Built* lesson, students explore the transmission of heat through convection, radiation, and conduction. Students will discuss radiant heat and how it can be used to heat a house. They will also discuss the pros and cons of an in-floor heating system and how it compares to other heating methods. In part two, students will conduct an experiment to find out what sort of flooring is best suited to use over in-floor heating.

CURRICULUM OUTCOMES

Taken from the New Brunswick Grade 7 Science curriculum.

GENERAL CURRICULUM OUTCOMES

GCO 1: Students will use scientific inquiry and technological design skills to solve practical problems, communicate scientific ideas and results, and make informed decisions while working collaboratively.

SPECIFIC CURRICULUM OUTCOMES

SCO 1.2: Students will collect and represent data using tools and methods appropriate for the task.

SCO 1.4: Students will work collaboratively on investigations to communicate conclusions supported by data.

NEW BRUNSWICK GLOBAL COMPETENCIES ACHIEVED¹

- Critical Thinking and Problem-Solving
 - Learners engage in an inquiry process to solve problems, as well as acquire, process, interpret, synthesize, and critically analyze information to make informed decisions.
 - Learners formulate and express questions to further their understanding, thinking, and problem-solving.

LEARNING OBJECTIVES

Learners will

- identify the differences between convection, radiation, and conduction,
 - compare and contrast different home heating methods, and
 - label different everyday examples of heat transmission as convection, conduction, or radiation.
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MATERIALS

- Video: *The House That STEM Built: In-Floor Radiant Heating*.
 - Chart paper and markers.
 - Copies of “Convection, Conduction, or Radiation”.
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¹ https://www2.gnb.ca/content/dam/gnb/Departments/ed/pdf/K12/curric/competencies/NBCompetencies.pdf?fbclid=IwAR1ldrZs1gFgiNm8rC4oz7Fmx6mSn-6t_QJkenev0eD33rZ-foYYn6bmdmc also available at <https://tinyurl.com/nb-competencies>

BEFORE CLASS

Print off copies of “Convection, Conduction, or Radiation”, 1 per pair.

WARM UP: 10 MINUTES

GROUPING: 3 EQUAL GROUPS

- Break students into 3 equal groups. Each group gets one piece of chart paper and a few markers.
- Assign each group one of the heat transmission methods: conduction, convection, or radiation.
- Ask students to brainstorm any words, ideas, or thoughts they have about each type of heat transmission.
- Once students have finished brainstorming, ask them to circle their top 3 terms, ideas, or examples to help them best illustrate their type of heat transmission to the class.
- Ask a volunteer from each group to share their top 3.

ACTIVITY: 40 MINUTES

GROUPING: 3 EQUAL GROUPS, INDIVIDUAL

Allow students to stay in their groups from the warm-up activity with their brainstorming sheets. Watch *The House That STEM Built* video. Let students know that if they see something in the video that they could add to their brainstorm sheet they are more than welcome to. Feel free to pause the video and ask some/all of the following open-ended questions to prompt discussions.

- 1:00 – If heat always moves from hot to cold, what do you think is happening when our bodies “feel cold”?
- 2:19 – Stop at this point and ask students to add any new information that might have been presented to their brainstorm sheets.
- 2:19 – What sort of heating methods are used in your house? If you had to guess, would they use conduction, convection, or

radiation?

- 3:16 – Why do you think radiators heat houses inefficiently? What factors could affect their efficiency?
- 4:55 – Why do you think the spaces built into the *DITRA HEAT* membranes are important? What purpose could they serve?
- 5:27 – Do you think the type of material that the tiles are made out of might make an impact on how well the radiant heating works? Why?

Ask students to add any final thoughts to their brainstorms before they are tucked away or displayed.

GROUPING: PAIRS

- Hand out copies of the “Convection, Conduction, or Radiation” activity.
- In pairs, students can cut out the different types of heat transmission and place them under the convection, conduction, or radiation category.
- Once students finish sorting the examples, ask them to come up with a unique example for each of the categories on their own.
- As groups are working, copy the table onto the board.
- When students finish up, sort through the answers as a class, taking the time to explain why each of the examples are the type of heat transfer mentioned. Take an extra moment to discuss why the example of the chair in the sun could be an example of radiation or conduction. Are there any others that could also fall into different categories?

CONCLUSION: 10 MINUTES

GROUPING: ENTIRE CLASS

Tomorrow the class will do an experiment that looks at different materials and how they absorb or transfer heat. We will also be

making a house blueprint taking into consideration the 3 types of heat transmission. As a class, co-construct some success criteria for tomorrow's class and lab. What are some things that need to be considered? Leave the success criteria up for tomorrow's class.

DIFFERENTIATION

CONTENT

Use *The House That STEM Built* video to spark a conversation about heating methods used in your

- school,
- school bus,
- house, and
- local swimming pool.

PRACTICE

Are there any professionals in your area who might be a good resource who could bring in materials and resources for your students?

Students can watch and host discussions in smaller groups (4–6 students) or as individuals instead of as a full class.

PBS Learning Media has a simulation that walks through each of the types of heat transmission and provides examples. It could be used as a different medium.²

PRODUCT

In groups, students can come up with their own examples of different types of heat transmission and deem them conduction, convection, or radiation.

Students can reflect in a science journal on which type of heating is best suited for their homes, vehicles, and schools.

² <https://www.pbslearningmedia.org/resource/lsp07-sci-phys-thermalenergy/thermal-energy-transfer/> also available at <https://tinyurl.com/pbs-simulation>

EXTENSION

Where do we see the different types of heat transmission in our daily lives? How many can you think of in nature? Do you often see convection, conduction, and radiation all happening together or separately? Investigate a natural phenomenon, (e.g., fog, thunder and lightning, breeze, heat circulation in warm-blooded animals, greenhouse effect) and explain how heat transmission plays a role.

Take a look at convection, conduction, and radiation by making popcorn! All you need for this lab-type activity is a Jiffy Pop, a hot air popper, and a bag of microwave popcorn and a microwave. Get students to explain how the kernels heat to popping temperature with each method.

LESSON TITLE: IN-FLOOR RADIANT HEATING PART 2**TOTAL TIME: TWO 60-MINUTE PERIODS****BRIEF DESCRIPTION**

In the second part of this *The House That STEM Built* lesson, students are going to test and decide what sort of materials are best suited for in-floor heating floors. They will create a hypothesis, conduct an experiment, record their results, and come to a conclusion. While they wait for their experiment, in teams students will build a floor plan for a hypothetical house and include heating sources based on what they learned in the previous lesson.

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NEW BRUNSWICK GLOBAL COMPETENCIES ACHIEVED³

- Critical Thinking and Problem-Solving
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 - Learners formulate and express questions to further their understanding, thinking, and problem-solving.

LEARNING OBJECTIVES

Learners will

- create a hypothesis based on prior knowledge,
 - conduct an experiment and record data,
 - come to a conclusion based on data, and
 - use knowledge of heat transfer to heat a hypothetical house.
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MATERIALS

- Video: *The House That STEM Built: In-Floor Heating*.
- Copies of “The House That *You* Built” (1 per group of 3).
- Copies of “Tile Comparison” lab template (1 per student).
- Medium-sized square of carpet (approximately 30 cm × 30 cm).
- Medium-sized square of laminate flooring (approximately 30 cm × 30 cm).
- Medium-sized square of stone tile or tile that conducts heat well

³ https://www2.gnb.ca/content/dam/gnb/Departments/ed/pdf/K12/curric/competencies/NBCompetencies.pdf?fbclid=IwAR1ldrZs1gFgiNm8rC4oz7Fmx6mSn-6t_QJkenev0eD33rZ-foYYn6bmdmc also available at <https://tinyurl.com/nb-competencies>

(approximately 30 cm × 30 cm).

- Medium-sized square of plywood or wood tile (approximately 30 cm × 30 cm).⁴
 - Source of radiant heat (e.g., heating lamp, direct sunlight, etc.).
 - Instrument to measure temperature (e.g., forehead thermometer).
 - Examples of blueprints that you can share with the class.
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BEFORE CLASS

- Print off copies of “The House That *You* Built” sheets (1 per group of 3).
- Print off copies of the “Tile Comparison” lab template (1 per student).
- Collect all of the materials needed for the experiment.

WARM UP: 10 MINUTES

GROUPING: ENTIRE CLASS

Today we are investigating radiant heat. Yesterday we watched a video about in-floor radiant heating. Today we are going to investigate which types of tiles would be the best suited for this type of floor.

- Hand out a copy of the “Tile Comparison” lab to each student. Have a brief discussion about what sort of characteristics would be the most desirable when it comes to choosing a tile for your toasty in-floor heated room. Should it absorb heat or conduct it? Should it heat up slowly or fast? Will colour have an impact?
- Once you have a list of desirable characteristics, show students

⁴ Feel free to add more flooring materials to the experiment to get a better variety of the options available.

the 4 tiles (or more if you choose) that will be tested today. Ask them to make a hypothesis as to which tile will be the best and jot it down on their lab sheet.

- Place the 4 tiles either in direct sunlight or under a heating lamp and leave for 20 minutes.

ACTIVITY PART A: 20 MINUTES

GROUPING: GROUPS OF 3

- While we wait for the tiles, put students into groups of 3 and give them a copy of the “The House That *You* Built” sheet.
- Ask students in teams to create a blueprint for a 3 bedroom, 2 bathroom house. This house can look however they like but must include at least 3 different heat sources with at least 2 different types of heating (radiation, convection, conduction). Ask them to think about the examples we went over yesterday and how they might help with the task at hand. Blueprints can be created on graph paper or by using programs like Minecraft Education (<https://education.minecraft.net/en-us/homepage>) or RoomSketcher (<https://www.roomsketcher.com/>) which allow students to create their visions digitally.
- Display or present an example of a blueprint for inspiration.

ACTIVITY PART B: 20 MINUTES

GROUPING: GROUPS OF 3, ENTIRE CLASS

- Check in on your tiles, and ask students to gather around as you either move the tiles out of the sun or turn off the lamp. Take the temperature of each of the tiles and ask students to write down the data on their lab page.
- Tell students that they are going to wait 5–7 minutes and retake the temperature of each of the tiles to see if they have changed.
- During this time, students can return to their tables and share some of the heating methods that they chose for their hypothetical house.

CONCLUSION: 10 MINUTES

GROUPING: ENTIRE CLASS

- Retake the temperature of each of the tiles and ask students to record it in their data table.
 - Allow students the rest of the class to represent their data in a graph and make a conclusion based on their results. Were their hypotheses correct? Which tile would you choose to use in your own house?
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DIFFERENTIATION

CONTENT

Convection or conduction could be used to compare insulating and conducting properties of different materials available.

Swap out tiles for other types of material to demonstrate their insulating or conductive capacities.

PRACTICE

PBS Learning Media has a simulation that walks through each of the types of heat transfer and provides examples. It could be used as a different medium.⁵

Lab reports can be filled out in groups.

If supervision and materials allow, more than one experiment can take place.

PRODUCT

Instead of creating a blueprint for a house, ask students to create one

⁵ <https://www.pbslearningmedia.org/resource/lsp07-sci-phys-thermalenergy/thermal-energy-transfer/> also available at <https://tinyurl.com/pbs-simulation>

for any sort of structure they are familiar with.

Provide more than 3 different material types (plastic, metal, etc.) and get each group of students to investigate one of them. Compare them all to each other.

Ask students to make a commercial about the best type of tile to use and why. Ask them to explain the properties that make their product the best.

EXTENSION

Take a look at convection, conduction, and radiation by making popcorn! All you need for this lab-type activity is a Jiffy Pop, a hot air popper, and a bag of microwave popcorn and a microwave. Get students to explain how the kernels heat to popping temperature with each method.

Radiant heating can be a great way to equally heat a room. Are there types of radiant heat that can be harmful? Are there types that are more harmful than others? Investigate the implications of different types of radiant heat.

Convection, conduction, or radiation?

Take a look at the following examples. They all represent a type of heat transfer. In pairs, cut out the examples and place them under the convection, conduction or radiation category on the next sheet. When you have finished, come up with an example of each on your own to add.

<p>Operating a hot air balloon</p> 	<p>Incandescent light bulb</p>	 <p>A spoon handle in a hot bowl of soup</p>
<p>A radiator in your bedroom</p>	<p>Popping popcorn in the microwave</p> 	<p>A greenhouse</p>
<p>Heating a pan on the stove</p> 	<p>An ice cube melting in your hand</p>	<p>Sitting on a plastic chair that has been in the sun</p> 
<p>Making toast in a toaster oven</p>	<p>Standing beside a campfire</p> 	<p>Boiling water</p>

Convection

Conduction

Radiation

Convection	Conduction	Radiation

Answer Key

<p>Operating a hot air balloon</p> <p>Convection</p> 	<p>Incandescent light bulb</p> <p>Radiation</p>	 <p>A spoon handle in a hot bowl of soup</p> <p>Conduction</p>
<p>A radiator in your bedroom</p> <p>Convection</p>	<p>Radiation</p> <p>Popping popcorn in the microwave</p> 	<p>A greenhouse</p> <p>Radiation</p>
<p>Conduction</p> <p>Heating a pan on the stove</p> 	<p>An ice cube melting in your hand</p> <p>Conduction</p>	<p>Conduction or radiation</p> <p>Sitting on a plastic chair that has been in the sun</p> 
<p>Making toast in a toaster oven</p> <p>Convection</p>	<p>Radiation</p> <p>Standing beside a campfire</p> 	<p>Boiling water</p> <p>Convection</p>

TILE COMPARISON LAB

PURPOSE

What is the purpose of today's lab? Why are we doing this exercise?

HYPOTHESIS

What do you think will happen? I predict that...

MATERIALS

- Medium-sized square of carpet (approximately 30 cm × 30 cm).
- Medium-sized square of stone tile or tile that conducts heat well (approximately 30 cm × 30 cm).
- Medium-sized square of plywood or wood tile (approximately 30 cm × 30 cm).
- Source of radiant heat (heating lamp, direct sunlight, etc.).
- Instrument to measure temperature (e.g., forehead thermometer).

PROCEDURE

1. Place all three of the tiles in direct sunlight or under a heat lamp.
2. Set a timer for 20 minutes.
3. Remove the tiles from the heat source.
4. Take the temperature of each of the tiles and record them in your table.
5. Leave the tiles out of the heat for 5–7 minutes.
6. Retake the temperatures of the tiles and record.

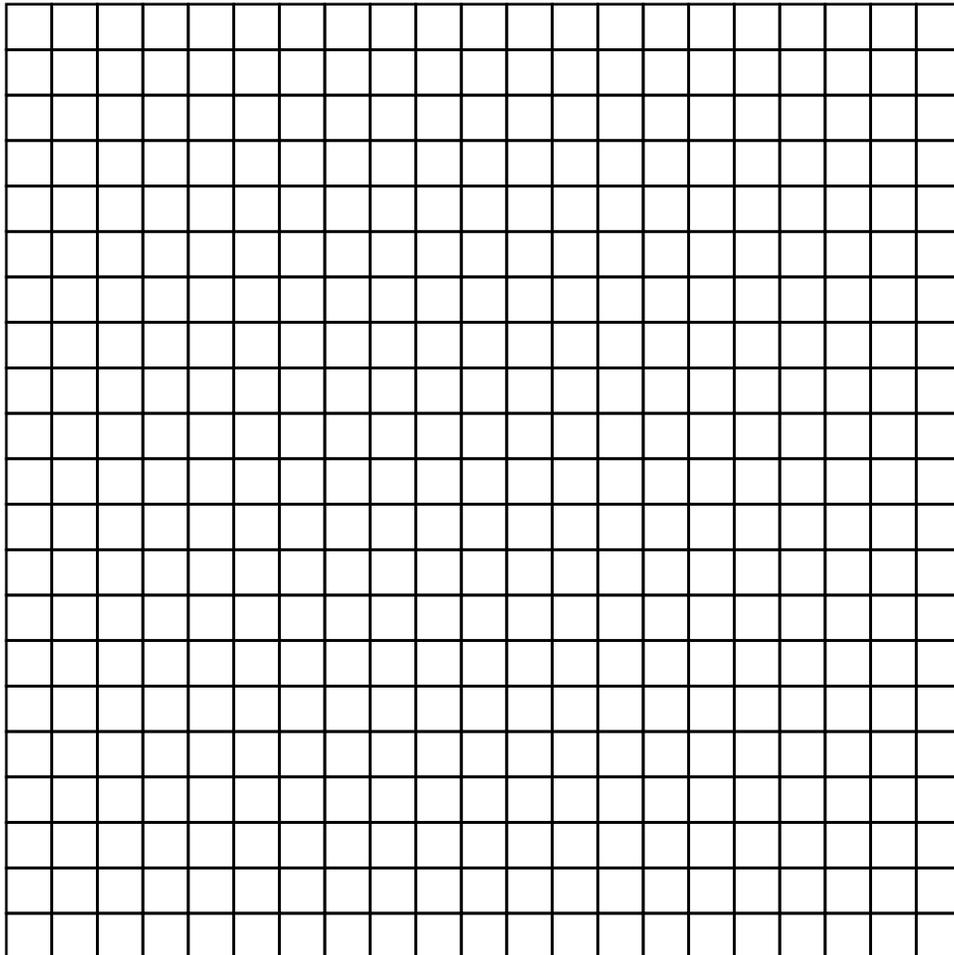
DATA

Tile materials	Tile 1 _____	Tile 2 _____	Tile 3 _____	Tile 4 _____
1st temperature measurement				
2nd temperature measurement				

RESULTS

Use the grid paper below to graph the ability of each of the flooring materials to warm up and retain heat over time. Which material would be the best to use with in-floor radiant heating?

TITLE: _____

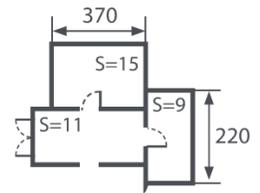


CONCLUSION/QUESTIONS

1. Which of the tiles was the warmest after the first temperature measurement?
2. Which tile held the heat best?
3. Which tile would be the best option if you wanted to cover your in-floor heating system in your home?
4. Are there any other materials that you would consider?



THE HOUSE THAT **YOU** BUILT



Have you ever thought about building a house? One of the major aspects of building is deciding how you are going to heat it. Create a blueprint of a 3 bedroom, 2 bathroom house (include a kitchen and other rooms if you like). This house can be as big or small as you want. Include 3 different sources of heat and 2 different heating types (convection, conduction, or radiation). Mark the location of each heat source on the blueprint and explain the placement of it. What type of heating transmission does it use? Feel free to use extra sheets or graph paper if you need. Time to design!