Instructional Sequence

Overview

Galactic Gloop Zoo is an iPad game that addresses concepts related to heat energy and heat transfer. Its focus is on the common misconceptions that students have about heat and heat transfer. This instructional sequence provides resources to help you link the game to your teaching unit, a PowerPoint presentation, several linking activities, discussion questions and "quick writes". It also indicates optimal times you can make links.

Links to The Next Generation Science Standards*:*

PS3.B: Conservation of Energy and Energy Transfer

- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-d)
- Energy is transferred out of hotter regions or objects and into colder ones by the processes of conduction, convection, and radiation. (MS-PS3-c)

Learning Goals:

Students should know that:

- Heat energy travels from an object that is at a higher temperature to an object at a lower temperature.
- Heat can be transferred in three different ways, conduction, convection and radiation.
- Insulators work to keep a substance at a constant temperature.

Misconceptions about Heat Transfer:

1. *The Direction of Heat Transfer:* Students may believe that heat moves from a colder object to a warmer object or that both "heat" and "cold" are transferred at the same time.
2. *Insulators:* Students may think that blankets and coats are sources of heat rather than that they keep us warm by trapping heat.

I Pad Game Play: Introductory Exploration

Give students ample free play time to explore the game before you begin your instructional unit. Pre-assign this game as homework for two days before you begin your instruction on heat and heat transfer. Students should play the game for at least 30 minutes. Some students may need help with the game instructions, if they are not familiar with the iPad.

On the first day back in class after the students have played the game as homework, begin the class with a Quick Write. Give students 10-15 minutes to answer the following questions:

- What was the problem that was going to stop the "Galactic Zoo's Creature Fest" from opening?
- How did the Zoo Keeper try to solve the problem?

Collect students' written responses and have a brief conversation about their answers.

Classroom Instruction: Heat Energy and Heat Transfer

Your unit might cover broad topics such as types of energy, energy transformation and energy transfer. This game focuses specifically on heat energy and heat transfer. The game can help students visualize many of these concepts. Implement your unit as usual, including any hands-on activities, video-clips, and reading and writing assignments.

PowerPoint: The heat energy and heat transfer power point will serve as a complement to your instruction. You may want to use the entire PPT as an introduction to instruction or as a review after instruction. **Take time to carefully review the PowerPoint beforehand.** You may want to use certain slides and not others and you may want to pause the PPT after certain slides to ask students questions or to emphasize certain ideas.

A typical unit about heat and heat transfer includes concepts such as heat energy, temperature, direction of heat transfer, conduction, convection and radiation. Heat transfer by conduction is usually introduced first, since students have much experience with situations where conduction occurs.

Conduction

- The ***PowerPoint*** can be used to introduce or review the concept of conduction. Slides 4-6 address conduction and slide 11 presents an example of conduction.

- ***Linking Activity***

The following linking activity will help students make connections between your instruction and the game.

Feel the Heat

> *Teaching Tip* – The game can be played either in the classroom or outside. You may need to create sufficient space in the classroom by moving desks around or you may take this game out in the hallway or outdoors, if there isn't enough classroom space.

"Feel the Heat" is a game that addresses the nature of heat transfer through conduction. The purpose of the game is for students to experience the direction of heat transfer and the correlation between the temperature of the water molecules and the movement of the water molecules.

Divide students into two equal groups. The students in Group 1 represent cold water molecules and the students Group 2 represent hot water molecules. Each student in Group 1 gets one wrapped candy and the students in Group 2 get five pieces of wrapper candy. [If you don't want to use candy, then you could use other items such as marbles, coins, or counters] Remind students that hot molecules move a lot while cold molecules do not move much. Also, heat flows from warmer (faster) to cooler (slower) molecules until they are all have the same amount of energy (candy).

Each group forms a line facing the other group. The students act like water molecules and the speed of their movement corresponds to the amount of energy (candy) they have. Tell students that if they are cold water, they must walk placing one foot in front of the other, heel to toe. The warm kids walk with regular steps. As you lose energy (candy) your steps get smaller.

Student should move about the room randomly and when they bump into another water molecule (student) they transfer energy. If the other molecule (student) has less energy than they do, they give the other student one candy.

Conversely, if they have less energy (fewer candies) they get one piece of candy from the other student. If the energy is same (both have same number of candies), there is no transfer of energy (candy). The students adjust their speed of movement to reflect their new level of energy after they have transferred energy through conduction.

This game comes to an end when all students have the same amount of energy (three pieces of candy) and are moving at about the same speed. This activity from start to finish may take about 15 to 20 minutes.

Sense Making Discussion
Hold a class discussion about the similarities and differences between what students did and this activity and how conduction occurred in the game.

- What do the candies in the activity represent?
- What is the relationship between the number of candies each of you had at the beginning and at the end of the game to the speed of your movement?
- Describe the process of conduction you experience in the activity?

Game Connection – Level 6 in Galactic Gloop Zoo explores conduction. In this level, the egg, which is very hot, needs to be cooled in order for it to hatch. To achieve this goal, Walker Gloops, along with Stan the Zookeeper, transfer heat through conduction. Stan, whose temperature is zero degrees, must come into contact with the Walker Gloop, whose temperature is minus one hundred degrees. Stan's movement initiates heat transfer by conduction. Stan gives heat to the Walker Gloop and the Walker Gloop touches the egg. The close up shows how conduction works. Heat transfers from warmer objects to cooler objects.

Now is a good time to project **Level 61** on a screen or SmartBoard. Enter the password "teacher feature" to access the Level. This Level is equivalent to Level 6 in the game and illustrates conduction. Play the level and ask students if they have something new to add to their ideas about the similarities and differences between the activity and the game experience. Use the following questions to guide the conversation:

- Describe how conduction takes place in the level 6 of the Galactic Gloop Zoo game.
- Did you notice anything new?

Following the discussion, use the questions below as a **Quick Write.** Give students 10-15 minutes to answer the questions.

- Write a rule to explain how "heat energy" is transferred in the **Feel the Heat** activity and the Galactic Gloop Zoo game.

Collect students' responses and conduct a class discussion about their answers.

Classroom Instruction Cont.'
Heat transfer by convection is usually introduced after conduction. Even though students have much experience with situations where convection occurs, this concept is more abstract than conduction where heat transfer occurs through direct contact. Continue with your unit as usual, including any hands-on activities, video-clips, and reading and writing assignments.

Convection

- The ***PowerPoint*** can be used to introduce or to review the concept of convection. Slides 9, 10, and 13 address this concept.

- **Linking Activity**

The following linking activity will help students make connections between your instruction and the game.

Mix the Heat

The purpose of this activity is for students to understand that heat transfers from the "warmer" object to the "colder" object until both objects reach the same temperature. The activity is also an example of heat transfer by convection. This activity may be done by students in small groups or as a demonstration.

Students predict what will happen when two equal amounts of water at different temperatures are mixed. Ask students or student volunteers, if you are doing a demonstration to measure the temperature of two half-full beakers of water. (Let's say they find that the temperature of the water in one beaker is 30^0 C and the temperature of the water in the other beaker is 15^0 C.) Next, have students predict what the temperature of the water will be after the two beakers of water are combined. Students should write down their predictions on the whiteboard or a piece of paper.

Students should share their prediction with a partner and provide a rationale for their thinking. The teacher should circulate listening to student explanations. Most students may predict that water temperature of the combined beakers will be 15^0 C because they think that 15 ^{0}C water will be subtracted from the 30 C. Some may think that water temperature of the combined water will be 22 C (average temperature of the two beakers) and a few may think that combined water temperature will be 45^0 C (adding the water temperatures).

Students collect data to test their prediction. Mix the two beakers of water and ask a student to take the temperature of the water which should be approximately 22 ^{0}C. Have students write down an explanation for their observation. This may be a good time to introduce or review the idea of *Thermal Equilibrium* – objects transfer heat until both objects reach the same temperature.

Hold a class discussion about the similarities and differences between what students did and this activity and how convection occurred in the game

Sense Making Discussion

Hold a class discussion about the similarities and differences between what students did and this activity and how conduction occurred in the game.

- What was your prediction? And why did you make that prediction?
- Were you surprised by the outcome of the experiment? If so, why?
- Why is the temperature of the combined water the average of the two temperatures of the water in the beakers?

Game Connection – Level 10 in Galactic Gloop Zoo explores the concept of convection. In this level, Stan the Zookeeper has to transfer heat to the egg with the help of both the Flying Gloop and the Walker Gloop. First, Stan transfers heat to the Flying Gloop, who moves down when its temperature falls below minus ten degrees. The Flying Gloop then transfers heat energy to the Walker Gloop, who after receiving heat, is able to move across the barrier into the liquid atmosphere. The heat energy from Walker Gloop is transmitted through convection to the liquid which in turn warms the egg enabling it to hatch.

Now is a good time to project **Level 63** on a screen or SmartBoard. Enter the password "teacher feature" to access the Level. This Level is equivalent to Level 10 in the game and illustrates convection. Play the level and ask students if they have something new to add to their ideas about the similarities and differences between the activity and the game experience. Use the following questions to guide the conversation:

- Describe how convection takes place in the level 10 of the Galactic Gloop Zoo game.
- Did you notice anything new?

Following the Sense Making discussion, use the questions below as a **Quick Write.** Give students 10-15 minutes to answer the questions.

- How is the method of heat transfer in the **Mix the Heat** activity similar to the way heat is transferred in Galactic Gloop Zoo?

Classroom Instruction Cont.'

Radiation, energy transfer by electromagnetic waves, is usually the last type of heat transfer introduced. Even though students have experience with feeling heat from the sun, the idea that heat travels through space, which is a vacuum is particularly abstract. Radiation isn't heat, but it transfers heat. Continue with your unit and introduce heat transfer through radiation. Use any hands-on activities, video-clips, and reading and writing assignments.

Radiation

- The ***PowerPoint*** can be used to introduce or to review the concept of radiation. Slides 7, 8 address radiation and Slide 12 provides an example of radiation as seen in the game.

This would be a good time to show **Level 62** on a screen or SmartBoard. Enter the password "teacher feature" to access the Level. This Level is equivalent to Level 9 in the game and illustrates radiation. Play the level and ask students if they have something new to add to their ideas about the similarities and differences between the activity and the game experience. Use the following questions to guide the conversation:

- Describe how radiation takes place in the level 9 of the Galactic Gloop Zoo game.
- Explain how heat is transferred by radiation?

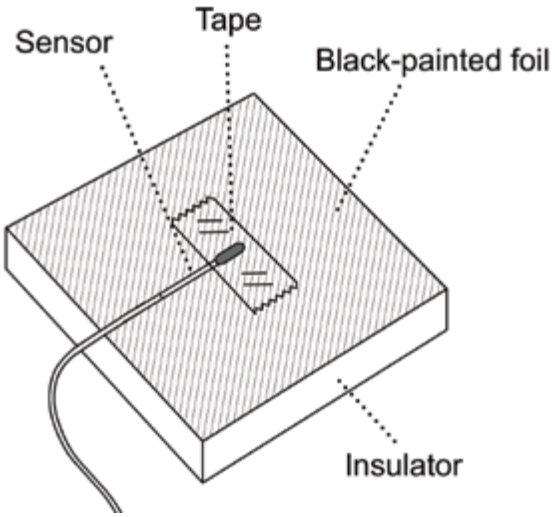
- **Linking Activity** Edmund Hazzard, *"Now You're Cooking! Heat transfer labs: From basic recipe to full inquiry. Science Scope (NSTA) September 2012*

Radiation
A simple "radiation meter," consisting of a fast-response temperature sensor taped to a black-painted foil surface on foam insulation, allows students to explore radiative transfer at ordinary temperatures (Figure 6).

Have students build the simple infrared radiation meter shown in Figure 6 below.

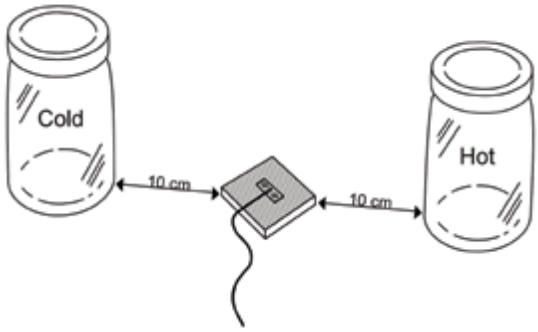
Students aim the radiation meter upward (toward the ceiling), toward a jar filled with hot water, and toward a jar filled with ice water (Figure 7). (**Note:** Use glass if the water is over 60°C, as plastic bottles will melt.) The temperature settles after about 30 seconds. The results vary about 1°C up or down from room temperature

A SIMPLE INFARED RADIATION METER (Figure 6) *Courtesy of The Concord Consortium*



INFRARED RADIATION EXPERIMENT (Figure 7)
Place various materials, such as glass, plastic bags of various colors, or paper between the IR meter and the hot water jar to see if they transmit IR radiation.

Courtesy of The Concord Consortium



1. Test whether the jar radiates if it is wrapped in foil or paper. Test the effect of different distances from the IR meter to the object.

2. Test the effect of different water temperatures.
3. Demonstrate how you can be sure the effect is due to IR radiation and not convection or conduction.
4. Test which materials, such as aluminum foil or paper, reflect IR

Game Connection: Level 11 in the game shows the process of heat transfer by radiation. The level begins in the liquid medium and moves into the gaseous atmosphere. Stan gains heat from the heat source (Static Gloop) and transfers it to the Flying Gloop that moves up when its temperature is above 10 degrees. The heat from the Flying Gloop radiates (see the halo around the Gloop) as it moves up and the heat is transferred to Walker Gloop. The air heats up and is circulated as convection currents to heat up the egg.

This would be a good time to show students **Level 64** on a screen or SmartBoard. Enter the password "teacher feature" to access the Level. This Level is equivalent to Level 21 in the game and illustrates all different environments (gas, liquid, and vacuum). It also shows that conduction and convection do not take place in a vacuum.

Once you have completed your instruction about radiation, use the question below as a **Quick Write.** Give students 10-15 minutes to answer the questions.

- Describe how conduction, convection and radiation play a role in losing heat through a double-pane window.

Collect student responses and conduct a class discussion about their answers.

Instruction Cont.'

Finally, it is important to insure that students understand the direction of heat transfer from warmer objects to cooler objects. Split the Difference is an excellent culminating activity that addresses the misconception related to the direction of heat transfer. This important idea connects all three types of heat transfer – Conduction, Convection, and Radiation.

- **Linking Activity**

  Direction of Heat Transfer

  Split the Difference game is an excellent culminating activity that addresses the misconception related to the direction of heat transfer. This important idea is a common theme connecting all three types of heat transfer – Conduction, Convection, and Radiation.

  Split-The-Difference

  This is a simple war-style card game, which can be played by groups of three

students with any deck of cards and a score sheet. Its purpose is to illustrate the directionality rules of heat transfer:
1. Heat goes to cold.
2. More goes to less.
3. Movement stops when the heat is the same in both objects.

The face cards are removed from the deck so that 40 number cards remain. The remaining deck is shuffled well and separated into two equal piles.

Each of two players gets one of the piles of 20 cards, face down. The third player is in charge of the scoring.

The score sheet consists of a number line, going from -10 to +10, a reminder of the rules of directionality and the conventions (red=hot, black=cold; red numbers are positive integers, black numbers are negative integers) and a set of empty tables of 20 rows and 2 columns, one for player A and one for player B.

The Scorer writes the initials of the two players into the top of the first chart.

Player A and player B each turn over the top card of their pile.

* If the open cards are A (red 6) and B (black 4),
the scorer says that player A's heat points go to player B because ***heat always goes to cold***. Now the question is how many heat points B gets. The number line shows that the difference between -4 (black) and +6 (red) is 10 units. So if you split the difference, player B gets 5 points. The scorer writes ”5” into the first row in the B column.

* If the cards are A (red 6) and B (red 4),
the scorer says that player B gets the points because ***more always goes to less***. The difference between +4 and +6 is 2, so if you split the difference, player B gets 1 point. The scorer writes ”1” into the first row of the B column.

* If the cards are A (black 6) and B (black 4),
the scorer says that player B gets the points because ***more always goes to less*** and since the difference between -6 and -4 is also 2, splits the difference and writes ”1” into the first row of the B column.

* If the cards are A (black 6) and B (red 4),
the scorer says that player A gets the points because ***hot always goes to cold*** (regardless of number).. Since the difference between -6 and +4 is also 10, the scorer splits the difference and writes ”5” into the top row of the A column.

* If there is a number tie (a red 4 and a black 4),
red goes to black because ***hot always goes to cold***, and

* if there is a number and color tie (two black 4s or two red 4s), neither player gets any points.

The game continues for 20 rounds until all the cards have been used. Each pair of cards is put on a disposal pile after the scorer has entered the points into the column of the player who gets the points in the round.

When all cards have been used up, the scorer adds up the points for both columns. The player with the most heat points wins the game.

Teachers can use the game to illustrate both the ***directionality of the flow of heat*** and the notion of ***balance***. The number line and the black = cold & negative integer while red = heat & positive integer convention can be used to illustrate that splitting the difference means the movement of points from heat/high to cold/low makes the counts equal. So, if you start with A = higher heat (6 red) and B = lower cold (4 black) and split the difference (5), you end up taking 5 points away from player A (6 **-** 5 = 1) and giving 5 points to player B (-4 **+** 5 = 1), so they balance out at 1 positive heat point each and movement stops when they are balanced. If you start out with the same color but different numbers (red/black 6 and 4), you split the difference and take 1 point away from the higher card holder (6 **-** 1 = 5 or -6 **-** -1 = -5) and give it to the lower card holder (4 **+** 1 = 5 or -4 **+** -1 = -5).

Sense Making Discussion

- How are points awarded to a player in the game of Split-the-Difference?
- Is there a similarity between how points are transferred from one player to another in Split-the-Difference and how heat is transferred between Stan and the different types of Gloops? If so, how are they similar?