Endeavor STEM Teaching Certificate Project
Kira Peasley
July 10, 2020

5E Integrated STEM Lesson Plan

For a Thermal Energy unit in grade 6 Science

Lesson Title: Understanding temperature and how heat transfer occurs

Author: Kira Peasley

Topics: Heat, temperature, thermal energy, insulators, conductors, heat transfer

Focus Questions: What is heat? How is temperature recorded? How is heat transferred? How can we use our knowledge of heat transfer and insulators to keep a soda or seltzer can cold?

Targeted Grade Level: grades 6, 7

Time Needed: 8-12 class periods or approximately 2 weeks

Subject Integration: Science, Math, Literacy

Justification:

The main subject for this series of lessons is science. This is part of the thermal energy unit in my 6th grade science class. Prior to doing the activities listed, students will have had some instruction on heat transfer (conduction, convection, and radiation), temperature, insulators and conductors. They will also have learned how to record appropriate information in their science journals or lab notebooks, when doing an experiment. These include such things as listing materials used, variables, hypotheses, accurate data charts, etc. The concepts of what is heat and how thermal energy transfer occurs will be investigated in depth through a series of activities listed in the 5E chart. These lessons include science skills as well. Students will make observations, record and analyze data, make hypotheses, conduct investigations, etc. Mathematics is integrated as well. Students will record temperature data and calculate degree of change. They will also make a bar graph using results from an experiment. Literacy is integrated when students write extended responses to questions, and when writing a conclusion using the CER method. Prior to doing this lesson, student will have had practice in writing complete sentences when answering questions, including recycling the question and editing for conventions. They will have also learned how to write an accurate claim, how to back it up with evidence, and connect the two with correct reasoning. They will have written at least one full conclusion paragraph using CER.

Standards:

NGSS Performance Expectations

MS-PS3-3: Apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer.

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

AFTER the 5E cycle of lessons, if you continue on with the "Save the Penguins Engineering Design Challenge" performance assessment, these standards are also covered:

MS-ETS1-1.	**Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
MS-ETS1-2.	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
MS-ETS1-3.	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
MS-ETS1-4.	**Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved**

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:

Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Construct and interpret graphical displays of data to identify linear and nonlinear relationships. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy and Energy Transfer** • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. ***For the "Save the Penguins" challenge:*** ***ETS1.A: Defining and Delimiting Engineering Problems*** • *The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.* ***ETS1.B Developing Possible Solutions*** • *A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.* • *There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.* • *Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.* • *Models of all kinds are important for testing solutions.* ***ETS1.C. Optimizing the Design Solution*** • *Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information*	**Energy and Matter** • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion) • The transfer of energy can be tracked as energy flows through a designed or natural system.

	for the redesign process—that is, some of those characteristics may be incorporated into the new design. • *The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.*	
Common Core State Standards: ELA/Literacy RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **Other** Math: DCS Math Competency - Data Analysis, Probability, and Statistics- design investigations and analyze data. ELA/Literacy: DCS ELA Competency - Writing Informative Texts: Write effectively to develop, summarize, and communicate information about topics and events.		

Measurable Student Learning Objectives:

Students will be able to:

- Explain that all objects contain *thermal energy* and that *thermal energy* is defined as the total energy of all the particles in an object or substance. (DOK level 1)
- Explain that *temperature* is a measure of the average kinetic energy of the particles in an object or substance. (DOK level 1)

- Explain that *heat* is not a "thing" but rather an idea or action; that *heat* is thermal energy moving from a warmer object or substance to a cooler object or substance. When thermal energy is transferred, it is called heat. (DOK level 2)
- Identify objects and substances as being either insulators or conductors based on the properties of the material(s) they are made of. (DOK level 2)
- Explain how insulators slow the movement of heat and how conductors allow heat to easily move through them. (DOK level 2)
- Identify what material(s) will keep a can of seltzer or soda cool for the longest time and be able to explain why. (DOK levels 2 and 3)
- Explain why objects of different materials feel like they are different temperatures even though they are all in an environment of the same temperature. (DOK level 3)
- Explain why coats and blankets make us feel warm. (DOK level 3)

<u>Nature of STEM:</u>

The *Nature of Science* themes that are addressed in this lesson are "Scientific knowledge is based on empirical evidence", "Scientific models, laws, mechanisms, and theories explain nature phenomena", and "Science addresses questions about the natural and material world." Students will use data in many ways. For example, they will observe ice cubes melting in bowls made of different materials. They will also use thermometers to record the temperatures of water in cans that are wrapped with different materials. Students will investigate the phenomenon of why objects *feel* like they are different temperatures even though they measure the same temperature. They will learn that *heat* is actually the movement of thermal energy from a warmer to cooler object or substance. Students will have questions about "the natural and material world" during these activities. For example, they may question why a tile floor feels cold and why a carpeted floor feels warm. Most students will also wonder why a wool sock is a better material than cotton to put around a cold can of soda in order to keep it cool. After all, we all have learned that wool sweaters and socks keep us warm, so wouldn't they also keep the soda warm? The activities in this unit push the students to think deeper about insulators and how they are not just useful for keeping things warm, they can also be used to keep heat from getting into substances that are cold.

The areas of the *Nature of Mathematics* that are addressed in this lesson include "the number system" and "statistics and probability." Students will need to calculate the degree of change in temperatures by finding the difference between the beginning and ending temperatures of water, during one of the experiments. They will also compare data from several samples in the experiment. Students will make a bar graph to analyze data from an experiment.

Engaging Context/Phenomena:

The engaging phenomenon for this lesson is about why objects *feel* like they are different temperatures even though they measure the same temperature. There are several ways to introduce this phenomenon and “hook” students into the topic. They are detailed in the 5E chart later in this document.

Data Integration:

Data will be collected by students in the form observations and temperature data using thermometers. Students will observe the melting of ice cubes in bowls and/or on spoons made of different materials. They will record the temperature of water in several seltzer or soda cans that are wrapped with different materials, every 20 minutes for 2 hours. They will use the beginning and ending temperatures to calculate the degree of change for each can. Then they will use that data to make a bar graph. They will then analyze the data to determine which material caused the least amount of temperature change in the can over the course of 2 hours.

Differentiation of Instruction:

All activities in this lesson should be accessible to all students regardless of their learning style. Possible modifications may be needed for those students with physical disabilities, who may not be able to hold or read a thermometer. They should be partnered with an appropriate classmate who can help them read the temperature on the thermometers. Magnifying glasses should be available, if needed, to see numbers on the thermometer. Calculators should be available to use when doing the math involved in finding the difference in temperature. For students with an IEP who require scaffolding, a data collection chart can be provided to them to fill in temperature data during the experiment. When writing a conclusion paragraph, IEP students who have difficulty with writing, may need support from a special educator and/or para educator. Students, both regular ed. and special ed., may be given a CER planning chart to help with writing the conclusion paragraph. Prior to this lesson, students will have been taught how to write a conclusion using CER and they will have used the planning chart previously.

Real-life Connection:

This lesson connects to everyone because all students have worn a coat and have used a blanket to keep them warm. Most students will have had experience with drinks, in a can or bottle that get warm over time once they are taken out of a refrigerator. This lesson will teach students why coats and blankets make you feel warm and why cold cans of soda or seltzer warm up over time, once taken out of a refrigerator. Also, everyone has held an ice cube and knows how it feels. This lesson will teach students why the ice cube feels cold and why it melts in their hand.

Possible Misconceptions:

A common misconception people have is that coats and blankets are *warm*. They don't quite understand that the coat or blanket alone is not necessarily warm, but it keeps us warm because the material it is made up of is an insulator, thus it traps body heat or blocks heat from our body from moving through the material. Many people think that metal objects feel cold because they are cold. They don't realize that the metal feels cold because it acts as a conductor to conduct heat away from your hand. Finally, there is a misconception about coldness. We like to say that we can feel the "coldness" of an object, for example, an ice cube or a cold glass of lemonade. But in fact, we are not necessarily feeling "cold"; we are sensing the movement of thermal energy from the warmer object to the cooler object. It is the "heat" that is moving, not the cold.

Lesson Procedure:

5E Model	5E Objectives
ENGAGE	The **ENGAGE** stage should take one class period. 1)To access prior knowledge on the topic, assign the "Objects and Temperature" assessment probe from *Uncovering Student Ideas in Science volume 1: 25 Formative Assessment Probes* by: Page Keeley, Francis Eberle, and Lynn Farrin NSTA Press, 2005. Save the results to discuss later in the 5E cycle. https://drive.google.com/file/d/1QYTwzeuuY7PdwRiZH_16AwFUZ5zzbkES/

	view?usp=sharing 2)Do one or more of the following to "hook" your students further and engage them in the concept. • Ask your students to put one hand on their opened notebook (so it's on a page, not the front cover) and one hand on the metal leg of the chair or stool they are sitting on, and ask them what they think the temperature of the paper and chair leg are. Don't say, "which is colder or warmer?" Let the students come up with their own ideas. They will likely say that the metal leg of the chair/stool is colder than the notebook paper. Then use an Infrared thermometer to find the temperatures of both and show the class that they are the same. Why? How is that possible? Students record their thoughts in their journals. • Take the temperature of the air in the classroom and share it with the class. Then ask the students to hold their hands up in the air to feel it, then put their hand flat on the table top or desk. Ask them how the table feels in comparison to the air. Students will likely say that it feels cooler than the air. Then use an Infrared thermometer to find the temperature of the table top or desk and show the class that it is the same temperature (or very close to) as the air. Why? How is that possible? Students record their thoughts in their journals. • Read the "Party Meltdown" story from *Yet More Everyday Science Mysteries: Stories for Inquiry-Based Science Teaching* by: Richard Konicek-Moran NSTA Press, 2011. Discuss the story with your class. *Please note: I do not have a link to this story because the book is at my school and I cannot enter the school to get it, due to the Covid-19 pandemic. The gist of the story is that a group of kids put ice cubes into plastic and metal bowls and left them on a table. When they went to get them an hour or so later, the ice cubes in the metal bowl were almost completely melted while the ice cubes in the plastic bowl were not melted. The kids wonder why, talk about the reasons, and come up with ideas to explain. After reading the story to my students, I ask them which kid, from the story, they agree with most and why. Later in the 5E cycle we will recreate the scenario in class. Usually I add a third bowl, made of glass, to the experiment.* **Assessment:** At this stage, formative assessment occurs when the teacher listens to students' ideas about heat transfer and temperature of objects as they are doing the hook activities. The teacher also reviews the results of the "Objects and Temperature" probes, and take notes on which students got the correct answer, how close their explanations were, what possible misconceptions students have, etc. **Standards addressed:** This aligns with MS-PS3-3: Apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer and the DCI PS3.A: Definitions of Energy Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

<table>
<tr>
<td>EXPLORE</td>
<td>
The EXPLORE stage should take 1-2 class periods.

1)Give time for students to explore and investigate their questions. Have thermometers and temperature probes available, as well as several objects of different materials including metal, plastic, and wooden spoons and bowls. Student could:

Touch objects in the classroom and record how they feel (temperature wise)
Use a thermometer, temperature probe, or IR thermometer to find the temperature of objects in classroom
Put ice cubes on spoons or trays of different materials (plastic, metal, wooden) and observe melting
Conduct the “Cold Metal” science snack from Exploratorium https://www.exploratorium.edu/snacks/cold-metal

Students should record all their observations in their science journals. This could be done as stations around the classroom.

2)After students do some exploring, show the following videos. Give time for students to share and talk about what they saw in the clips.

Show only the first 1 minute of this video https://www.youtube.com/watch?v=yXT012us9ng

And then show this one https://www.youtube.com/watch?v=vqDbMEdLiCs

Assessment: At this stage formative assessment occurs when the teacher observes students’ exploration of the phenomena. The teacher takes notes as she/he listens to student conversations and watches them exploring. The teacher also collects the science journals to review what students have recorded.

Standards addressed: This aligns with MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. And the DCIs PS3.A: Definitions of Energy: Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. PS3.B: Conservation of Energy and Energy Transfer: Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
</td>
</tr>
<tr>
<td>EXPLAIN</td>
<td>
The EXPLAIN stage will take 2-3 class periods.

Re-create the “Objects and Temperature” assessment probe as a class experiment. Discuss the results with the class. Students attempt to explain why all the objects were the same temperature in the end. The teacher clarifies as needed.
Re-create the scenario in the “Party Meltdown” story. Do this as a whole class experiment. Put several ice cubes in a metal

</td>
</tr>
</table>

	bowl, plastic bowl, and glass bowl. Try to get bowls of relatively the same size and put the same amount of ice cubes in each bowl. Students will observe the ice cubes over the course of the class period. They can take turns looking at the ice throughout the class period. Take pictures of the ice in each bowl every 30 minutes or so. Keep the experiment going when the class ends and another class comes in. You can share the progress from the first class with your second class using the pictures (can be uploaded and shown on smartboard) and share the final results with your first class the following day. The ice will melt the fastest in the metal bowl and slowest in the plastic bowl. The glass bowl results will be somewhere in between. Have the students explain *how* the ice melted and *why* it melted at different rates in the different bowls. Encourage the use of the terms thermal energy transfer, insulator, conductor, heat, etc. The teacher clarifies as needed. Students should record observations and questions in their science journals or lab notebooks. • While the "ice in bowls" experiment is happening, students are to work on the following class assignments to further their understanding of the concepts: o Watch two BrainPop videos – *Heat* and *Temperature*, and do the quiz that comes with each. Each quiz has 10 multiple choice questions. You can choose to print out the quizzes for students to fill in, or have them do the interactive quiz on the website and report their results in Google Classroom. This can be done in partners or individually. https://www.brainpop.com/ o Read "Temperature and Heat" from ck12.org/ https://docs.google.com/document/d/1Yv50WtR8iebrXep8j0moqb0ugqU6j8p53rXpdmYeXc0/edit?usp=sharing o Watch the segment about heat in the Bill Nye video, which is linked in the ck12.org document **Teacher notes:** I list all of the class assignments in an assignment in Google Classroom. Students regularly use Google Classroom to access websites, complete assignments, and upload work. All of my students have chromebooks and there are headphones available in the classroom. For students who may need assistance with focus on completing these assignments, a para educator may choose to take a small group of students to an alternate room to watch the BrainPop videos together and/or read the ck12 article together. I also allow pairs of students to sit in the hallway and work together. These class activities can also be worked on during the experiments done during the elaborate stage. **Assessment:** Formative assessment grades can be recorded from the results of the BrainPop quizzes. Teacher may also collect science journals to review what the students recorded during the "Ice in bowls" class experiment **Standards addressed:** This aligns with MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. And the DCIs PS3.A: Definitions of Energy: Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. PS3.B: Conservation of Energy and Energy Transfer: Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

ELABORATE	The **ELABORATE** stage will take 4 -5 class periods depending on how long your blocks are. There are two experiments to do. The first one can be done in one class period. The second one will need 3-4 class periods. 1)“Energy on the Move” teacher demonstration and experiment. Materials needed: 1 empty disposable water bottle (Poland Spring 16.9 oz or equivalent is best), 1 balloon, warm water, cold water, room temperature water, 2 large glass or plastic bowls for Part 1: the demonstration, 6-9 small plastic bowls for Part 2 of the lab, several towels. The first part of this lab is done as a teacher demonstration. Students will fill in their observations on the paper. Set up ahead of time by putting a balloon over the opening of the empty water bottle. Have warm water ready. (I have an electronic teapot in my classroom that I use to heat up water for experiments). Have cold water ready. (I put a gallon of water in the refrigerator the day before, when I know I’m going to need cold water. I also make plenty of ice cubes the day before and have them available in a cooler in my classroom all day. That way I can easily add ice cubes to water when I need it to be cold.) In front of the class, set up a large bowl with warm water and a large bowl of cold water. Follow directions on the paper to demonstrate the actions. This activity will extend students’ thinking on what heat is. The second part of the activity is a simple experiment students can easily do in class or at home. It is the “Discover Activity” on page 176 of this textbook: *Prentice Hall Science Explorer, Motion, Forces and Energy*, Pearson Education, Inc. 2005. You can set up 2 or 3 stations around the room with 3 bowls of water at each station: warm, room temp, cold. Have students take turns doing the actions for the activity. Have a towel available at each station for students to dry their hands. While students are waiting their turn to put their hands in the different temperature waters, they can work on filling in the rest of the paper and continuing to do the class activities from the explain stage of this lesson. **Teacher notes:** At this point most students should have a good understanding of what happens when thermal energy is added to or taken away from a substance. The answers to the questions on the paper can act as a formative assessment on the concept. Especially the “Putting it all Together” part at the end of the lab, which is a good indicator of how well students are understanding the concept. 2) “Keep my Seltzer Cold” experiment. Follow directions on this link to conduct this experiment. Quick overview of experiment: 6-7 cans of seltzer filled with cold water, different materials wrapped around each can, take temperature of water in cans every 20 minutes for 2+ hours. This experiment will further students’ understanding of how insulators work to slow down the movement of thermal energy and how conductors allow heat to move through them easily. During this experiment students will also read thermometers, record and

	analyze temperature data, make a bar graph, and write a conclusion. All details can be found in the document. **Assessment:** The paper that goes with the "Energy on the Move" experiment should be counted as a formative assessment grade. Students are encouraged to do their best work and to finish the paper for homework if not done in class. The teacher may also collect science journals to assess how well students did writing all the components of an investigation for the "Keep my Seltzer Cold" experiment. **Standards addressed:** This aligns with MS-PS3-3: Apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer, and MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. And the DCIs PS3.A: Definitions of Energy: Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. PS3.B: Conservation of Energy and Energy Transfer: Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
EVALUATE	The **EVALUATE** stage will take one class period. • The conclusion paragraph written for the "Keep my Seltzer Cold" lab can be used as a summative assessment. If this is the first time you are having students write a conclusion using the CER method, I recommend having it be a formative assessment. If students have written conclusions before, this can be a summative assessment. Here is the rubric I use to grade CER conclusions. • You can also give this test as a summative assessment. In this summative there is a snowman "concept cartoon" which can be used as an assessment on its own. It is an excellent way to evaluate how well students understand the concepts. The concept cartoon can be found at https://blogs.glowscotland.org.uk/glowblogs/klduodeportfolio/2015/11/09/concept-cartoons/ or in the book *Science Formative Assessment, 75 Practical Strategies for Linking Assessment, Instruction, and Learning* by Page Keeley, NSTA press, 2008. On this snowman "concept cartoon" I also give my students the option of writing their own idea if they don't agree with any of the choices in the speech bubbles.

- Another great formative assessment is “The Mitten Problem” which is in the book *Uncovering Student Ideas in Science.* This assessment probe is geared more towards grades 4 & 5, but you may choose to assign it as a formative or summative assessment during any stage of this 5E series of lessons.
  The Mitten Problem teacher notes
  http://static.nsta.org/connections/elementaryschool/201103TheMittenProblem.pdf - This is the Mitten Problem if the above link doesn’t work.
- **Optional Engineering project:** I have also done the “Save the Penguins” engineering design challenge at the end of my thermal energy unit. This is a group project that will last 1-2 weeks. Some of the activities in this 5E lesson came from the “Save the Penguins” project. The whole project can be found here: http://www.auburn.edu/~cgs0013/ETK/SaveThePenguinsETK.pdf ©2009 Christine G. Schnittka, Ph.D. in cooperation with the Virginia Middle School Engineering Education Initiative (updated version 4-6-14). It is also written in the magazine *Science Scope*, November 2010, NSTA. My write up for the project is all in this document.

Assessment: The conclusion paragraph for the “Keep my Seltzer Cold” experiment will be graded as a summative assessment. The end of unit test can also be used as a summative assessment.

Standards addressed: This aligns with MS-PS3-3: Apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer, and MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. And the DCIs PS3.A: Definitions of Energy: Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. PS3.B: Conservation of Energy and Energy Transfer: Energy is spontaneously transferred out of hotter

	regions or objects and into colder ones.

Teacher Background:

Teachers should have a good understanding of thermal energy transfer, heat, insulators and conductors. I usually teach this unit after I teach a unit on forms of energy. There are several resources teachers can read ahead of time, if they need a refresher on these concepts. I recommend reading the teacher notes in the formative assessment probes for "Objects and Temperature" and "The Mitten Problem". There are excellent explanations in the *Understanding Student Ideas in Science* books. There are also a series of books called "Stop Faking It!" from NSTA that are great resources for teachers. More teacher notes can be found within the 5E chart.

Resources:

I used ideas from the following to design this 5E series of lessons.

http://www.auburn.edu/~cgs0013/ETK/SaveThePenguinsETK.pdf ©2009 Christine G. Schnittka, Ph.D. in cooperation with the Virginia Middle School Engineering Education Initiative (updated version 4-6-14)
https://sites.google.com/a/wmtps.org/savethepenguins/about-project
https://sites.google.com/a/wmtps.org/savethepenguins/thermal-transfer-review
https://www.teachengineering.org/lessons/view/ucd_heat_lesson01
https://blogs.glowscotland.org.uk/glowblogs/klduodeportfolio/2015/11/09/concept-cartoons/
https://www.pbslearningmedia.org/resource/lsps07-sci-phys-thermalenergy/thermal-energy-transfer/#
https://www.exploratorium.edu/snacks/cold-metal
https://www.ck12.org/book/ck-12-physical-science-for-middle-school/r3/section/17.1/
www.brainpop.com
https://www.nextgenscience.org/
https://learningcenter.nsta.org/products/symposia_seminars/anaheim/uncovering/MittenTeacher.pdf
http://static.nsta.org/connections/elementaryschool/201103TheMittenProblem.pdf

Magazine - *Science Scope*, November 2010, NSTA.
Magazine - *Science Scope*, December 2011, NSTA.

Science Formative Assessment, 75 Practical Strategies for Linking Assessment, Instruction, and Learning by Page Keeley, NSTA press, 2008.

Uncovering Student Ideas in Science Volume 1: 25 Formative Assessment Probes by: Page Keeley, Francis Eberle, and Lynn Farrin, NSTA Press, 2005.

Yet More Everyday Science Mysteries: Stories for Inquiry-Based Science Teaching by: Richard Konicek-Moran, NSTA Press, 2011.

Prentice Hall Science Explorer, Motion, Forces and Energy, Pearson Education, Inc. 2005.

Energy: Stop Faking It! Finally Understanding Science So You Can Teach It by William C. Robertson, PhD, NSTA Press, 2002.

Air, Water, and Weather: Stop Faking It! Finally Understanding Science So You Can Teach It by William C. Robertson, PhD, NSTA Press, 2005.

https://www.youtube.com/watch?v=yXT012us9ng
https://www.youtube.com/watch?v=vqDbMEdLiCs
https://www.youtube.com/watch?v=f1eAOygDP5s&feature=related