## STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

| | |
|---|---|
| **STEM Unit Title** | **Lunchbox of the Future** |
| Economic Cluster | Advanced Materials and Manufacturing |
| Targeted Grades | 3-4 |
| STEM Disciplines | Science Technology, Engineering and Math |
| Non-STEM Disciplines | English Language Arts, Social Studies |

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## Section I: STEM Unit Overview

**Unit Overview**

Working people, school children, and others pack meals to take with them that will be eaten later in the day, however there may not be access to refrigeration or the capability to heat their food. Students will design and build a lunchbox that will maintain two different temperatures in different sections of the lunchbox. Students will survey their classmates to inform them about the needs of the lunchbox users and measure the area and perimeter of lunchboxes and common foods or items included in their lunches. Students will research the thermal conductivity of various materials and apply their findings within their design. Student designs will be tested using thermometers to measure change in temperature over an extended time period.

**Essential Question**

How can our choice and use of materials help us limit the amount of heat energy transferred from one location to another?

**Enduring Understanding**

Heat is a form of energy that can be transferred from one location to another. Certain materials and methods can limit that transfer of energy. Everything is composed of matter, which exists in different states and has specific, distinguishing properties.

**Engineering Design Challenge**

Many people, both children and adults, pack food to eat later in the day. Keeping cold foods cold is essential to limiting bacterial growth and ensuring a healthy lunch. Depending upon where the person is planning to eat, there may not be a way to heat their food, which limits their food options. They may not be able to have both hot and cold food or drinks. Your challenge is to create a lunchbox that will keep hot foods hot and cold foods cold for as long as possible. The lunchbox should be lightweight, have a pleasing appearance, include at least two separate compartments for hot and cold foods, and be able to easily hold common food items or containers without being too large to carry to work or school.

**Time and Activity Overview**

| Day | Time Allotment | Actvities |
|---|---|---|
| 1 | 50 minutes | Pretest, Lunchbox Survey, and Brainstorming |
| 2 | 50 minutes | Steps of the Engineering Design Process -- Melt an Ice Cube |
| 3 | 50 minutes | Testing Materials for Thermal Conductivity |
| 4 | 50 minutes | Building a Materials Selection Matrix<br>Identifying Opportunity Cost |
| 5 | 50 minutes | Measuring Area and Perimeter of Lunchboxes and Common Lunch Items |
| 6 | 50 minutes | Introduction of the Engineering Design Challenge<br>Individual Sketch<br>Team Discussion with Design Selection Matrix<br>Team Design |

| | | |
|---|---|---|
| 7 | 50 minutes | Build lunchboxes |
| 8 | 50 minutes | Test Lunchbox Design<br>Begin Marketing the Lunchbox |
| 9 | 50 minutes | Lunchbox Redesign |
| 10 | 50 minutes | Prepare Marketing Presentations |
| 11 | 50 minutes | Marketing Presentations and Post-test |

## Pre-requisite Knowledge & Skill

Prior to teaching this lesson, students should know:

Students should understand that matter can exist in solid, liquid or gas form.
Students should understand that solids have a definite shape and volume. They should also know that liquids have a definite volume, but take the shape of their container.
Students should be able to read a thermometer in Celsius.
Students should be able to measure length to the nearest whole unit (inches or centimeters) using a ruler.

# Academic Content Standards

| Add Standard | Mathematics |
|---|---|
| Grade/Conceptual Category | 3 |
| Domain | Operations and Algebraic Thinking |
| Cluster | Represent and solve problems involving multiplication and division. |
| Standards | 1. Interpret products of whole numbers, e.g., interpret 5 × 7 as the total number of objects in 5 groups of 7 objects each. For example, describe a context in which a total number of objects can be expressed as 5 × 7. |

| Add Standard | Mathematics |
|---|---|
| Grade/Conceptual Category | 3 |
| Domain | Operations and Algebraic Thinking |
| Cluster | Multiply and divide within 100. |
| Standards | 7. Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 × 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers. |

| Add Standard | Mathematics |
|---|---|
| Grade/Conceptual Category | 3 |
| Domain | Measurement and Data |
| Cluster | Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects. |
| Standards | 2. Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). |

| Add Standard | Mathematics |
| --- | --- |
| Grade/Conceptual Category | 3 |
| Domain | Measurement and Data |
| Cluster | Geometric measurement: understand concepts of area and relate area to multiplication and to addition. |
| Standards | 5. Recognize area as an attribute of plane figures and understand concepts of area measurement.<br>a. A square with side length 1 unit, called “a unit square,” is said to<br>have “one square unit” of area, and can be used to measure area.<br>b. A plane figure which can be covered without gaps or overlaps by n unit squares is said to have an area of n square units. |

| Add Standard | Mathematics |
| --- | --- |
| Grade/Conceptual Category | 3 |
| Domain | Measurement and Data |
| Cluster | Geometric measurement: understand concepts of area and relate area to multiplication and to addition. |
| Standards | 7. Relate area to the operations of multiplication and addition.<br>b. Multiply side lengths to find areas of rectangles with whole-number side lengths in the context of solving real world and mathematical problems, and represent whole-number products as rectangular areas in mathematical reasoning. |

| Add Standard | Mathematics |
| --- | --- |
| Grade/Conceptual Category | 3 |
| Domain | Measurement and Data |
| Cluster | Geometric measurement: recognize perimeter as an attribute of plane figures and distinguish between linear and area measures. |
| Standards | 8. Solve real world and mathematical problems involving perimeters of polygons, including finding the perimeter given the side lengths, finding an unknown side length, and exhibiting rectangles with the same perimeter and different areas or with the same area and different perimeters. |

| Add Standard | Mathematics |
|---|---|
| Grade/Conceptual Category | 4 |
| Domain | Operations and Algebraic Thinking |
| Cluster | Use the four operations with whole numbers to solve problems. |
| Standards | 3. Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. |

| Add Standard | Mathematics |
|---|---|
| Grade/Conceptual Category | 4 |
| Domain | Number and Operations in Base Ten |
| Cluster | Use place value understanding and properties of operations to perform multi-digit arithmetic. |
| Standards | 5. Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models. |

| Add Standard | Mathematics |
|---|---|
| Grade/Conceptual Category | 4 |
| Domain | Measurement and Data |
| Cluster | Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit. |
| Standards | 3. Apply the area and perimeter formulas for rectangles in real world and mathematical problems. For example, find the width of a rectangular room given the area of the flooring and the length, by viewing the area formula as a multiplication equation with an unknown factor. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 3 |
| Strand | Speaking & Listening |
| Topic | Comprehension and Collaboration |
| Standard | 1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 3 |
| Strand | Speaking & Listening |
| Topic | Presentation of Knowledge and Ideas |
| Standard | 4. Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly and at an understandable pace. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 3 |
| Strand | Language |
| Topic | Conventions of Standard English |
| Standard | 3. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 3 |
| Strand | Language |
| Topic | Knowledge of Language |
| Standard | 3. Use knowledge of language and its conventions when writing, speaking, reading, or listening. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 4 |
| Strand | Speaking & Listening |
| Topic | Presentation of Knowledge and Ideas |
| Standard | 4. Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant descriptive details to support main ideas or themes; speak clearly at an understandable pace. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 4 |
| Strand | Speaking & Listening |
| Topic | Presentation of Knowledge and Ideas |
| Standard | 6. Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 4 |
| Strand | Speaking & Listening |
| Topic | Comprehension and Collaboration |
| Standard | 1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 4 |
| Strand | Language |
| Topic | Conventions of Standard English |
| Standard | 1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. |

| Add Standard | English Language Arts |
|---|---|
| Grade | 4 |
| Strand | Language |
| Topic | Knowledge of Language |
| Standard | Use knowledge of language and its conventions when writing, speaking, reading, or listening. |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | 3 | |
| Theme | Communities: Past and Present, Near and Far | |
| Strand (pk-8 only) | Economics | |
| Topic | Economic Decision Making and Skills | |
| Content Standard | 14. Line graphs are used to show changes in data over time. | |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | 3 | |
| Theme | 14. Line graphs are used to show changes in data over time. | |
| Strand (pk-8 only) | Economics | |
| Topic | Scarcity | |
| Content Standard | 16. Individuals must make decisions because of the scarcity of resources. Making a decision involves an opportunity cost, the value of the next best alternative given up when an economic choice is made. | |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | 3 | |
| Theme | Communities: Past and Present, Near and Far | |
| Strand (pk-8 only) | Economics | |
| Topic | Production and Consumption | |
| Content Standard | 17. A consumer is a person whose wants are satisfied by using goods and services. A producer makes goods and/or provides services. | |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | 3 | |
| Theme | Communities: Past and Present, Near and Far | |
| Strand (pk-8 only) | Economics | |
| Topic | Financial Literacy | |
| Content Standard | 19. Making decisions involves weighing costs and benefits. | |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | 3 | |
| Theme | Communities: Past and Present, Near and Far | |
| Strand (pk-8 only) | Economics | |
| Topic | Financial Literacy | |
| Content Standard | 20. A budget is a plan to help people make personal economic decisions for the present and future and to become more financially responsible. | |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | 4 | |
| Theme | Ohio in the United States | |
| Strand (pk-8 only) | Economics | |
| Topic | Production and Consumption | |
| Content Standard | 23. Entrepreneurs organize productive resources and take risks to make a profit and compete with other producers. | |

| Add Standard | Social Studies | |
|---|---|---|
| Grade | 4 | |
| Theme | Ohio in the United States | |
| Strand (pk-8 only) | Economics | |
| Topic | Economic Decision Making and Skills | |
| Content Standard | 22. Tables and charts help people to understand information and issues. Tables organize information in columns and rows. Charts organize information in a variety of visual formats (pictures, diagrams, graphs). | |

| Add Standard | Science | |
|---|---|---|
| Grade | 3 | |
| Theme | Interconnections within Systems | |
| Topic | Matter and Forms of Energy | |
| Content Standard | All objects and substances in the natural world are composed of matter.<br>--Matter takes up space and has mass. | |

| Add Standard | Science | |
|---|---|---|
| Grade | 3 | |
| Theme | Interconnections within Systems | |
| Topic | Matter and Forms of Energy | |
| Content Standard | Heat, electrical energy, light, sound and magnetic energy are forms of energy.<br>--There are many different forms of energy. Energy is the ability to cause motion or create change. | |

| Add Standard | Science | Ohio |
|---|---|---|
| Grade | 4 | |
| Theme | Interconnections within Systems | |
| Topic | Electricity, Heat, and Matter | |
| Content Standard | The total amount of matter is conserved when it undergoes a change.<br>--When an object is broken into smaller pieces, when a solid is dissolved in a liquid or when matter changes state (solid, liquid, gas), the total amount of matter remains constant. | |

| Add Standard | Science | Ohio |
|---|---|---|
| Grade | 4 | |
| Theme | Interconnections within Systems | |
| Topic | Electricity, Heat, and Matter | |
| Content Standard | Energy can be transformed from one form to another or can be transferred from one location to another.<br>--Energy transfers from hot objects to cold objects as heat, resulting in a temperature change. | |

| Add Standard | Science | Ohio |
|---|---|---|
| Strand | | |
| Course Content | | |
| Content Elaboration | | |

| Add Standard | Fine Arts |
| --- | --- |
| Grade | |
| Subject | |
| Standard | |
| Benchmark | |
| Indicator | |

| Add Standard | Technology |
| --- | --- |
| Grade | 3 |
| Standard | Standard 6: Design<br>Students apply a number of problem-solving strategies demonstrating the nature of design, the role of engineering and the role of assessment. |
| Benchmark | Benchmark A: Describe and apply a design process to solve a problem. |
| Indicator | Design Process<br>1. Describe the purpose of the design process (e.g. a purposeful method of planning practical solutions to problems).<br>2. List the main elements of the design process—problem identification, possible solutions, refinement, analysis, decision, implementation and feedback.<br>Technical Communication<br>4. Make sketches to visualize possible solutions to a technological problem (e.g. sketch possible locations to more effectively place trash bins in the cafeteria using a computer drawing program or hand drawings). |

| Add Standard | Technology | |
|---|---|---|
| Grade | 4 | |
| Standard | Standard 6: Design<br>Students apply a number of problem-solving strategies demonstrating the nature of design, the role of engineering and the role of assessment. | |
| Benchmark | Benchmark A: Describe and apply a design process to solve a problem. | |
| Indicator | Design Process<br>1. Apply the design process to purposefully solve a problem (e.g., how to improve recycling at school and home).<br>2. Generate solutions for solving a problem using the design process with information collected about everyday technological problems.<br>Research and Development<br>3.Survey potential users to evaluate a solution to a technical problem (e.g., survey other students about which type of model plane they like).<br>Technical Communication<br>4. Make sketches and paper models to visualize possible solutions to a technological problem (e.g., use computer drawing programs to prepare cut-out patterns).<br>Redesign<br>5. Recognize when changes to a solution are needed to meet the requirements. | |

| Add Standard | Technology | |
|---|---|---|
| Grade | 3 | |
| Standard | Standard 6: Design<br>Students apply a number of problem-solving strategies demonstrating the nature of design, the role of engineering and the role of assessment. | |
| Benchmark | Benchmark B: Describe how engineers and designers define a problem, creatively solve it and evaluate the solution. | |
| Indicator | Innovation and Invention<br>1. Describe the importance of creativity in designing an object.<br>Strength and Materials<br>3. Recognize the importance of the materials to be used in a design (e.g. materials differ in strength, aesthetics, resistance to corrosion and wear). | |

| Add Standard | Technology |
|---|---|
| Grade | 4 |
| Standard | Standard 6: Design<br>Students apply a number of problem-solving strategies demonstrating the nature of design, the role of engineering and the role of assessment. |
| Benchmark | Benchmark B: Describe how engineers and designers define a problem, creatively solve it and evaluate the solution. |
| Indicator | Innovation and Invention<br>1. Describe how models are used to communicate and test design ideas (e.g., model truss designs are tested for weight loads using bridge building simulation software).<br>Strength and Materials<br>2. Describe the structural needs to be met when designing an object (e.g. in designing a bridge, the maximum weight to be supported must be decided).<br>Technical Careers<br>3. Identify different types of engineers (e.g., manufacturing, architects,automotive, ceramic, materials, environmental, civil, electrical, agricultural, safety, biological, audio, mechanical, chemical). |

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

| | |
|---|---|
| **Performance Task, Projects** | Experiment Worksheets, Rubric, Lunchbox Prototype, Peer Review, Presentations |
| **Quizzes, Tests, Academic Prompts** | Pretest, Post-test<br>Recorded Data on worksheets<br>Informal writing |
| **Other Evidence** (e.g. observations, work samples, student artifacts, etc.) | Sketches and Diagrams of Designs<br>Teacher Observations<br>Design Matrix<br>Materials Selection Matrix |
| **Student Self- Assessment** | Individual Design Matrix<br>Prototype Analysis and Reflection |

Technology Integration

## ADISC Technology Integration Model*

| | Type of Integration | Application(s) in this STEM Unit |
|---|---|---|
| A | Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners. | Interactive whiteboard<br>Internet |
| D | Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display. | Rulers<br>Thermometers<br>Calculators<br>Digital scales |
| I | Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods. | Thermometers |
| S | Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships. | Internet |
| C | Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration. | Interactive whiteboard or document camera<br>Digital camera |
| | **The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton* | |

Career Connections

## Career Description

Chemical Engineer- finds the right chemicals to make a lunchbox strong and safe to hold food

Engineering Management- plans and organizes the engineering project to design and produce the lunchbox with many people

Environmental Engineer- creates a lunchbox that could be made out of recyclable materials

Materials Engineering- creates the material that goes on the inside of a lunchbox; creates a lunchbox that will insulate food better

Industrial Engineering- helps the manufacturing process of making a lunchbox go smoothly through designs, materials, machines, and people

Manufacturing Engineering- deals with the production and manufacturing of the lunchbox from the beginning to the end of manufacturing

Petroleum Engineering- figures out how to obtain oil safely and effectively; this oil can be used to produce the plastic that is found in lunchboxes or to produce fuel for transporting the lunchboxes around the country

Systems Engineering- organizes and helps various people with different jobs to work together to make a lunchbox

Mechanical Engineering- designs, builds, and maintains machines to create the lunchbox (Gibbons, Grose, Home-Douglas, Loftus, Tran & Woolston, 2011).

Business- participate in the buying, selling, and the production of the lunchbox

Accounting- gathers, records, and interprets information about the financial part of the lunchbox business

Marketing- learns how to sell the lunchbox to many people

Finance- plans, raises money, and controls costs in the lunchbox business

Logistics and Materials Management- manages and coordinates the movement of raw materials through a business to create the lunchbox (The College Board, 2013).

## Section II: STEM Lesson Plan

**Title of Lesson** — **Lesson 1: Lunchbox of the Present**

**Time Required** — 50 minutes

**Materials**

Appendix A: Pretest (1 per student)
Appendix B: Engineering Design Challenge (1 per student)
Appendix C: Lunchbox Survey (1 per student)
Student lunchboxes (at least 1 per team)
Sticky notes (5-10 per student)
Chart paper and markers (optional)
Projector
https://www.youtube.com/watch?v=ERBL_uhBOxU

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**Objectives**

Students will collect data from lunchbox users (consumers) regarding the users' needs and wants.

**Instructional Process**

Lesson Preparation:
1. Make copies of printable resources for this lesson (pretest, survey). If desired, copies of all student resources can be printed and stapled or bound into a lab book. This will minimize the amount of papers misplaced and save time during each lesson.

2. Plan for students to work in teams of 3-4. Plan for diverse groupings of students.

3. Collect enough lunchboxes (not disposable bags) for each team to have at least one. If many students in your class pack their lunch in lunchboxes, students can use their own lunchboxes.

4. Check to see if the YouTube video at https://www.youtube.com/watch?v=ERBL_uhBOxU can be accessed in your classroom. Preview the video to determine if it is appropriate for your students.

Instructional Process:
1. Give students the pretest. Allow students approximately 20 minutes to complete the test. Explain to students that they will most likely not know the answers to all of these questions, but should try their best. Collect the pretest.

2. Ask the class if anyone packed their lunch today. Survey one or two of those who packed their lnuch about what they packed their lunch in. You can use these questions to begin and then ask related follow-up questions.

a. How many of you have packed something warm in your lunch today?
b. How many of you have packed something cold in your lunch today?
c. How many of you have packed both warm and cold foods today?
d. How do you keep your warm foods warm and cold foods cold?
e. Does everything fit easily in your lunchbox?
f. Would you pack different foods if your lunchbox were bigger or smaller?

3. Assign student teams and tables, and then give each team a lunchbox and at least 5 sticky notes per team member.

4. Have students make silent observations of the lunchbox (both inside and outside). Explain that they have 2 minutes to write or sketch as many observations about the lunchbox as they can and that each sticky note

should have only one observation

5. Explain that each student will share their observations with their team. This can be done in one of several ways:

a. Give each student one minute to share all of their observations, and then rotate around the table. Allow an extra minute or two at the end for students to respond to others' observations.

b. Have each student share one observation, and then rotate around the table. Students can respond to others' observations throughout the process. Allow 5-6 minutes for sharing and discussion.

c. Have students work to combine their sticky notes into stacks of similar observations. Allow 5-6 minutes for sharing and discussion.

6. As a whole class, have students share some of their most interesting observations. Record observations on the board or chart paper.

7. Distribute copies of Appendix B, the Engineering Design Challenge. Explain that each student is going to become a lunchbox entrepreneur. There are several terms the students will most likely not know. Explain that an "entrepreneur" is a person who takes a risk in making a new product. Have students share what they think are the risks that an entrepreneur takes in making a new product (people will not like it, people will not buy it, the entrepreneur may lose money).

8. Introduce the terms "producer" and "consumer." Explain that a producer is one who makes things and a consumer is on who uses things. (If you have previously discussed producers and consumers related to the food chain, help students make the connection to this.) Help students figure out that the company that made the lunchbox is the producer and the person who packs their lunch in the lunchbox is the consumer.

9. Introduce the "consumer survey" as a tool that entrepreneurs use to limit their risk. For example, if an entrepreneur who makes toys finds out that most people like superheros, then superhero toys would be a smarter choice. Discuss how asking only one person does not give enough information, but asking every single person takes too long, so only some people are surveyed.

10. Each student will need to give a consumer survey to 2-3 people to find out what they want or need in a lunchbox. They will need to find people who pack their lunch and ask them several questions.

11. Give students 2-3 survey papers and explain the survey process. (You can determine the limits of this assignment. This could be done in class, during lunch, during recess, or after school. Students could survey only members of their class, other classes in their grade, other grades, or friends from other schools. Provide appropriate time depending on the parameters you set for the survey.) Have each team add 1-2 additional questions in the space at the bottom of the page if needed.

12. If possible, show students the video "Lunch Box Safety *BE FOOD SAFE!*" on YouTube. https://www.youtube.com/watch?v=ERBL_uhBOxU. Discuss students' thoughts about the video.

13. Collect surveys once they are completed. Students will use this information to guide their decisions about how to market the lunchbox they design later in this unit.

## Differentiation

Heterogeneous teams allow for differentiation
Allow students to write or sketch their observations.

## Assessments

Pretest
Survey
Teacher observation

# Section II: STEM Lesson Plan

**Title of Lesson** — **Lesson 2: Quick Melt Challenge**

**Time Required** — 50 minutes

**Materials**

Resealable plastic sandwich bags (6 per team)
Ice cubes -- standard size (3 per team -- only one distributed at a time)
Permanent markers (1 per team)
Paper towels (for spills)
Appendix D: Engineering Design Process (1 per student)
Appendix E: Melting an Ice Cube Data Sheet (1 per student)
Scale, accurate to nearest gram (1 per team)
Sticky notes (several per student) OR blank copy paper (1-2 per student)
Freezer OR cooler
Engineering Design Process video at https://www.youtube.com/watch?v=6-lQwKPYDqk OR
Engineering Design Process video at https://www.youtube.com/watch?v=wE-z_TJyzil

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**Objectives**

Students will apply the engineering design process to the problem of quickly melting an ice cube. Students will collaborate with a partner to solve the problem.

**Instructional Process**

Lesson Preparation:
1. If students do not know how to use the scales, plan time to teach them how to use the scales to measure the mass (weight) of an object to the nearest gram.

2. Freeze enough ice cubes for all teams to have at least 3 ice cubes. Save 1 ice cube for the redesign.

3. Plan to split each group into partners. Teams will work first as partners and then rejoin into teams for the second part of the lesson.

4. Make copies of the Engineering Design Process Diagram (Appendix D) and the Melting an Ice Cube Data Sheet (Appendix E) for each student. To save paper, copy these 2-sided on one sheet of paper. Make one extra copy of The Engineering Design Process Diagram to post in the classroom.

5. Collect scales and ensure that they are in working order.

6. Plan to collect and refreeze the bags of water. This will help students see that matter/mass is conserved through the changes of state.

7. Check to see if the YouTube videos at https://www.youtube.com/watch?v=6-lQwKPYDqk and https://www.youtube.com/watch?v=wE-z_TJyzil can be accessed in your classroom. Preview the videos to determine if they are appropriate for your students and which you would prefer to use.

Instructional Process:
1. Briefly review the conversation from Day 1 about lunchboxes. Ask students if they thought any of the lunchboxes they saw were “perfect.” Have them share what kinds of problems they think people might have with their lunchboxes.

2. Distribute the Engineering Design Process diagram to the class. Explain that the best way to solve a problem is to make a plan and follow it.

3. If possible, show students one of the two videos about the engineering design process.

4. Look at the engineering design process diagram together. Discuss the steps with them and allow them to ask whatever questions they have. Refer back to the video as needed.

a. Every design challenge starts with a PROBLEM. Until something is perfect, it can be improved. Engineers spend a lot of time defining the problem to make sure that they are working on the right thing.

b. We start to think about the problem by asking QUESTIONS. We want to ask what other people have done to try to solve this problem. We want to ask who needs this problem solved. We need to take these questions seriously because questions are powerful tools.

c. After we get answers to some of our questions, we need to begin to THINK about many different ways to solve the problem. Most of the time, our first idea is not our best idea. Engineers come up with as many ideas as they can, then they share their ideas with others. We will get more ideas as we listen to each others' ideas.

d. After we have as many ideas as we can come up with, we will need to choose one DESIGN to fully develop. There are methods to choose the best design to create. Whichever design is chosen will need to be sketched in detail, labeled, measured, calculated, and communicated.

e. Once the design is chosen, we need to build and TEST that design. Engineers create a prototype, or model, to find out if their design will work to solve the problem. They make their prototype as closely as possible to what their true product should be so the test can be as accurate as possible.

f. The result of a test could be a working SOLUTION if your prototype meets all the objectives for the challenge. But more likely than not, there will still be room for improvement. Your design will probably FAIL in one way or another. Engineers love to fail because they learn where improvements can be made and they get valuable information from each failure. If this happens, we go back through the process again -- usually faster the second time -- and try again. We often call this a "redesign."

5. Divide the class into their teams, then split the teams into partnerships. Give each pair two resealable plastic sandwich bags.

6. Explain that each pair is going to get an ice cube and they have to try to melt it within four minutes. They must follow the following rules: a) The ice cube must stay in the bag at all times; and b) The bags must remain intact (not broken) and sealed at all times.

7. Tell students that they are going to practice the engineering design process as they complete this challenge. (Be sure to explicitly point out each step, especially if this is their first STEM experience.) Allow students to ask QUESTIONS to clarify expectations (explain that this is the first step in the engineering design process). Try not to hint at any possible solutions while answering student questions. The response "I don't know. Try it and find out." is a great way to encourage students not to depend on the teacher for answers.

8. Tell students to THINK (next step in the process) about how they can melt the ice cube. Give students two minutes to individually write or sketch ideas on sticky notes or paper. There should be NO talking during that time.

9. Give pairs two minutes to discuss their individual ideas. At the end of the two minutes, they should have decided on a DESIGN they want to implement.

10. Give each pair an ice cube and have them put the ice in one bag and place that bag inside the other bag. Have students weigh the ice cube/bag to the nearest gram. Have each team write the weight on their data collection sheet (Appendix E).

11. Tell students that they are going to have four minutes to TEST their design. Use a stopwatch or timer to track their time. During the testing phase, have one student write out the plan on the Data Collection Sheet while the other has the ice cube.

12. After four minutes, have everyone place their bags on the tables and determine how much their ice cube has melted: a little, about half, almost all, or completely. Explain that the designs that led to fully melted ice cubes were SOLUTIONS to the problem. Have students share what their designs were (their procedure) and tell

whether they found a solution.

13. Have each pair weigh their bags of water/ice to the nearest gram again and record the weight on the data collection sheet.

14. Have student pairs reassemble into their teams of four. Explain that we are going to work on a redesign. Teams that melted their ice cube completely, challenge them to do it faster. Teams that did not melt their ice cube completely can try to melt it completely. Allow them to ask QUESTIONS and THINK together about what they want to try next time. Allow two minutes for groups to come up with a new DESIGN.

15. Give each team two new bags. Distribute ice cubes and repeat the process.

16. Allow four minutes for student teams to TEST their designs. Use a stopwatch or timer to track their time. Have at least one member of the team write down the plan that they chose to follow.

17. After four minutes, have everyone place their bags on the tables and determine which ice cube are fully melted.

18. Discuss the students' results. Have teams share their procedure and their results. Have the students share anything that surprised them during the lesson today. Emphasize that engineers always collect data and analyze that data to help them make decisions.

19. Ask students to reflect on the steps of the engineering design process and how each step was accomplished within the quick melt challenge.

## Differentiation

Pairs or teams that are not able to sketch or write their designs within the brief planning time can simply discuss their plan verbally.
Pairs or teams may designate one team member to record the data and then transfer it to the other papers later.

## Assessments

Student data sheets
Teacher observations
Class discussion

# Section II: STEM Lesson Plan

**Title of Lesson**

**Lesson 3: Which Material is Best? A Thermal Conductivity Experiment**

**Time Required**

50 minutes

**Materials**

Appendix F: How Cold is Your Water? (1 per team)
Appendix G: Material Price List (1 per team OR display on board)
Thermometers (3 per team)
Plastic Cups (approximately 12 oz.) (1 per team)
Paper Cups (approximately 12 oz.) (1 per team)
Styrofoam Cups (approximately 12 oz.) (1 per team)
Various materials, amounts listed are per team:
--wool fabric (1 - 12"x12" square)
--cotton fabric (1 - 12"x12" square)
--fleece (1 - 12"x12" square)
--aluminum foil (1 - 12"x12" square)
--wood craft sticks (10)
--bubble wrap (1 - 12"x12" square)
--Styrofoam packing peanuts (approximately 20)
--cotton balls (approximately 20)
--paper napkin (1)
--paper (1 sheet)
Timer or Stopwatch (1 per team)
Reclosable plastic bags (2-3 per team)
Ice cubes (2-3 per team)
Pitchers with ice water (2-3)

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**Objectives**

Students will predict which materials are better insulators.
Students will understand that the loss of energy transfers heat from an object and that the loss can be limited by the use of certain materials.

**Instructional Process**

Lesson Preparation:
1. If your students do not know how to read a thermometer to the nearest degree, or if students have not used the Celsius scale, plan a time before this lesson to teach this.

2. If your students do not know how to make a line graph, plan to complete step 8 of the Instructional Process at a separate time before moving on to lesson 4. Ensure that students can plot the points on the grid and connect the points using lines (not making bars).

3. Gather the materials required for this lesson. The materials listed above represent materials that are easily accessible and commonly found in classrooms and schools. Other readily available materials can be added and materials that are not available can be omitted. The intention is to provide students with a variety of materials from which to choose, some of which will be good insulators and some of which will not be good insulators. Students will discover which materials will insulate against heat transfer and, hopefully, begin to notice properties that those materials have in common.

4. Adjust the materials listed in Appendix J to reflect the materials you have available. Adjust the cost of each item to reflect the rigor of the academic task appropriate for your students. This list will only be used as a reference for students as they test their materials today. It will be filled in later in this unit.

5. Make copies of Appendices F and G.

6. Make several pitchers of ice water, enough to fill each of the 3 cups each team will use. Each cup will need to be filled approximately half full.

Instructional Process:
1. Review the quick melt challenge from the previous lesson. Discuss the scientific concepts demonstrated in the challenge:

a) Any kind of energy can be transferred from one object to another. This can happen in different ways, but one way is when objects touch each other or collide into each other.

b) Heat is a type of energy which can be transferred from one object to another. This happened as heat from your bodies or from the room transferred to the ice cube, causing it to melt. Even though it made your hands feel cold, heat energy always moves from the hotter object to the colder object. The ice cube did not add cold, it took heat.

c) Matter (the amount of stuff that makes up an object) is conserved (does not change) as it changes from one state to another. This was demonstrated by weighing the bags with ice before and after melting the ice cubes. (Hopefully, if the bags did not break and were not opened, the mass of the bags with ice was the same or almost the same before and after.)

2. Discuss the term "insulation" as a material that limits the flow of energy from one place to another. Have students share their prior knowledge about insulation. Some students may be familiar with insulation in houses. Other examples of insulation include insulated cups (for coffee, etc.), insulation around electrical wires, and earplugs.

3. Explain that students will explore different materials to see which limit the flow of heat energy from their hands to an ice cube. Make sure that students understand that this will be the opposite of the quick melt challenge from the previous lesson. The goal is to learn what materials might keep an ice cube from melting. Explain that they will also be testing materials to see how easy they are to use. They are to test materials while waiting to check the temperature of the water in the cups.

4. Provide each team with 3 (approximately) 12oz cups: plastic, Styrofoam, and paper along with 3 thermometers. (If cups are different sizes use the same amount of water, about 6-8 oz. or 200-250mL, in each). Have each team predict which cup will keep the water the coldest and record their hypothesis on Appendix F.

5. Add an equal amount of cold water to each cup. (If ice is in the pitcher, strain out the ice cubes as you pour. No ice should be in the cups.) Place a thermometer in each cup and record the temperature in Celsius on the worksheet. If the thermometer needs to be stabilized use an index card with a hole or slit in the center to help hold it in place.

6. Set a timer for 10 minutes. When the timer beeps, have groups check the thermometers and record the temperature in each cup on Appendix I. Repeat every 10 minutes for a total of 40 minutes.

7. Distribute samples of each material to each team. In between measurements, students will be reviewing the materials provided by the teacher for insulation properties and how easy the material is to use. Do this by giving each student an ice cube in a plastic bag and encourage them to place different materials around the bag, one at a time and feel the temperature.

8. After 40 minutes, have the students record the last temperature. Using the recorded temperatures, have each student construct a line graph using a different color for each cup.

## Differentiation

Heterogeneous teams allows for differentiation.

## Assessments

Worksheet completion
Teacher observations

## Section II: STEM Lesson Plan

**Title of Lesson** — **Lesson 4: Materials Selection Matrix and Opportunity Cost**

**Time Required** — 50 minutes

**Materials**

Appendix G: Material Price List (1 per team OR display on board)
Appendix H: Materials Selection Matrix (1 per student)
Materials explored during Lesson 3 (1 set for display)
Interactive white board
Opportunity Cost video at https://www.youtube.com/watch?v=NwOYLV-L7pc

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**Objectives**

Students will create and compare a Materials Selection Matrix that will help them determine the best materials for their design based upon objective criteria.
Students will identify the opportunity cost of choosing materials for inclusion in their design.

**Instructional Process**

Lesson Preparation:
1. Copy Appendix H and (if desired) Appendix G.

2. Check to see if the YouTube video can be accessed in your classroom. Preview the video to determine if it is appropriate for your students.

Instructional Process:
1. Briefly review Lesson 3. Have students share some of the properties of the materials they observed. Have the sample set available for students to see and, if needed, feel. Have students share their thoughts about which materials seemed to keep the water cold or keep their hands from getting cold when holding the ice. Help students understand that these materials were good insulators (as discussed in Lesson 3). Make a list on the board of good insulators.

2. Have students share which materials they thought were easy to use when they tried to insulate the ice cubes. Make a list on the board of easy to use materials.

3. Discuss the Material Price List. Explain that the shoebox on the list will serve as the lunhbox and the students will use materials inside the shoebox to create their design. Make a list on the board of materials that are low in cost.

4. Explain that creating a good lunchbox will involve making hard choices. Some materials that are good insulators are not easy to use or are more expensive. Some materials that are easy to use are not good insulators. Some materials that are low in price are not easy to use.

5. Introduce the terms "scarcity" and "opportunity cost." Explain that scarcity means that there is not always enough of something for everything someone might want. Scarcity can mean not enough material, not enough money, not enough space, or not enough time. Opportunity cost means that in order to use one thing you will have to give up a different thing. This could be material, money, space, or time.

6. If possible, show the Opportunity Cost video at https://www.youtube.com/watch?v=NwOYLV-L7pc.

7. Have students imagine how scarcity and opportunity cost might affect their lunchbox designs. Examples might include not wanting to buy all of the most expensive materials, the class running out of one material or another because everyone wants to use it, not having enough room in the shoebox for all of the biggest materials.

8. Introduce the Materials Selection Matrix. Explain that each student will complete their own matrix, selecting

four materials that they would like to consider for their lunchbox design. They will be making economic decisions weighing the benefits and costs of each material. After each individual has completed the matrix, the teams will get together to compare their thoughts.

a) Choose four materials that you think will be good to use in your design. List these at the top of the matrix under the headings "Material 1," "Material 2," "Material 3," and "Material 4."

b) Rank the materials by insulation. Place a 40 under the material that you think did the best job at insulating the ice/water. Place a 30 by the material you think was next best, etc.

c) Rank the materials by cost. Consider how much of each material you would have to use. One piece of foil might be less than one piece of Styrofoam, but you might need a lot more foil, which could make it more expensive altogether. Place a 20 under the material that is least expensive. Place a 15 under the material that is next least, etc.

d) Rank the materials by how easy they are to use. Place an 8 under the material that is easiest, etc.

e) Add the three scores for each material. Write the total in the bottom row of the chart. The higher the score, the better you consider the material to be for your design.

9. Have teams get together and compare their matrices. As a team, discuss the materials and collaboratively answer the two questions at the bottom of the page.

## Differentiation

Students will need different levels of support while completing the matrix.
Heterogeneous groups will allow for greater student success.

## Assessments

Materials Selection Matrix
Teacher observations

## Section II: STEM Lesson Plan

**Title of Lesson**

**Lesson 5: How Big is Your Lunchbox?**

Time Required

50 minutes

Materials

3x5 index cards (1 per student)
Rulers (1 per student)
Lunchboxes (at least 1 per team)
Juice Boxes (at least 1 per team)
Sandwiches (2 bread slices stacked on top of each other) (at least 1 per team)
Plastic storage container (at least 1 per team)
Various other typical lunch items (at least 1 of each per team)
Calculators, if needed (1 per student)
Appendix I: Lunchbox Measurements Data Sheet (1 per student)

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Objectives

Students will find the area and perimeter of a lunchbox and various lunch items.

Instructional Process

Lesson Preparation:
1. Make copies of Appendix I.

2. Collect enough lunchboxes (not disposable bags) for each team to have one. If many students in your class pack their lunch in lunchboxes, students can use their own lunchboxes.

3. Gather materials required for this lesson, including supplies that student may need to solve the “Challenge” section of the Lunchbox Measurements table worksheet (graph paper, string, etc.). Lunch items listed above may be substituted based on the availability of items and the desires of the students.

Instructional Process:
1. Explain that in order to design a good lunchbox, an entrepreneur must make sure that people can fit the food they want to eat inside the lunchbox. This involves taking measurements. Explain that during this lesson, students will be measuring common lunch items to help them make sure that their lunchbox will be big enough to hold all the items.

2. Introduce (or review) the terms "area" and "perimeter." Explain that area is how much space an object takes up if it is sitting/standing on a surface. Perimeter is the distance around an object. Have students share in what situations they would use each measurement. (Example, area is how much of the playground is covered in grass or mulch while perimeter is how long the fence is that goes around the playground.)

3. Explain the mathematical formulas for finding the area and perimeter of a rectangle.

4. Give each student a ruler and a 3x5 index card. Have students label the short side of the card with the word "width" and the long side of the card with the word "length". Have students measure all four sides of the card and write the measurements on the card. Guide the students in finding the area and perimeter of the index card.

5. Distribute the lunchboxes, lunch items, calculators (if desired), and Appendix K to each team.

6. Go over the instructions on the worksheet with the class and let the class begin measuring their objects, calculating area and perimeter, filling out their tables, and answering the questions on the worksheet.

a) If students want to measure items from their own lunchbox, ensure that the foods are sealed in airtight packages (Re, plastic containers, sealed pouches, etc.).

b) When measuring the area and perimeter of the lunchbox, students should find the area and perimeter of the lunchbox's largest face.

c.) When measuring the area and perimeter of the other lunch items, students should find the area and perimeter of the side that would be on the bottom of the lunchbox.

d) Encourage students to collaborate as needed while making measurements, discussing their results, and comparing to verify that all measurements are as accurate as possible.

7. Once everyone is done filling out their table, discuss students' answers to the questions below.

a) Which object had the largest area? The smallest area?

b) Which object had the largest perimeter? The smallest perimeter?

c) What relationship, if any, do you see between area and perimeter?

d) When designing a lunchbox, which measurement is more important to take into consideration, area or perimeter? Why?

8. If time allows, have students try to come up with their own method of finding the area and perimeter of non-rectangular objects.

## Differentiation

Group students of various abilities together.
Make the "Challenge" question on the Lunchbox Measurements table worksheet optional or not, based on student ability.
Provide objects of irregular shapes for more advanced students.
Students who have difficulty measuring the rectangular items can set items on 1-inch grid paper and trace them. They can then count the sqares covered by the shape they traced.

## Assessments

Table worksheet completion/discussion
Teacher observation of group work

## Section II: STEM Lesson Plan

**Title of Lesson**

**Lesson 6: Designing the Lunchbox of the Future**

**Time Required**

50 minutes

**Materials**

Drawing paper for sketches (as needed)
Student copies of Appendix C: Lunchbox Survey (completed after Lesson 1)
Student copies of Appendix H: Materials Selection Matrix (completed in Lesson 4)
Student copies of Appendix I: Lunchbox Measurements Data Sheet (completed in Lesson 5)
Appendix J: Lunchbox Design Selection Matrix (1 per student)
Appendix K: Engineering Team Role Cards (1 per group)
Plastic disposable storage container, 1-2 cup size (1, for display)

**Objectives**

After individual and group brainstorming and sketch time, students will develop, and ultimately choose, a prototype design for their group's lunchbox.

**Instructional Process**

Lesson Preparation:
1. Make copies of Appendix J and Appendix K.

2. Prepare student teams. If necessary, pre-assign roles to students whose strengths would allow them to thrive in certain roles more than in other roles.

3. Choose a simple plastic storage container, such as those from Glad or Ziplock, with snap on lids. These will be used during design testing to hold hot and cold liquids and should prevent spills.

Instructional Process:
1. Reintroduce the Engineering Design Challenge (Appendix B) to the class. Explain that students will use the data collected on the previous days, including the surveys they gave to their classmates after lesson 1, to come up with a design for a lunchbox (what materials you will use, how it will be divided, etc.).

2. Show students the plastic storage containers that will be used during testing. Tell students that their design should allow both a hot container and a cold container of this size in their lunchbox.

3. Provide drawing paper to each student Remind students to use all the information they have learned from the previous lessons to imagine and sketch a design of a lunchbox that they think will best meet the design challenge's requirements. Encourage them to think about materials, handles, colors, designs, etc. Remind the students that this should be done independently.

4. After every student has completed his or her individual sketch, have each student share his or her design with his/her team. Each student needs to verbally explain their entire design. Remind the students to be as thorough as possible when describing the details of their designs with their teams.

5. Once all the students have shared their designs with their teams, pass out the Lunchbox Design Selection Matrix (Appendix J). Have each student individually score every design that was shared with the team. Students may need to be guided through this process. Follow the same procedure detailed in Lesson 4.

6. Once everyone is done filling out their design matrices, have the members of each team share their design matrices with one another and compare the scores that they gave to each design. Have the teams add the scores for each design to find each design's team total. Then compare the total scores for each design.

7. After each team is done comparing design matrices, have each group choose ONE design (or have them develop a new design that incorporates the best aspects of each design) that they think will best meet the requirements of the design challenge.

8. Introduce engineering team roles. Read through each of the job descriptions and assign (or let students choose) the roles they will take for the remainder of the unit.

9. Have the Design Engineer draw and label the team's final design on a new sheet of paper. This will be the design from which the team will construct a prototype in the following lessons

## Differentiation

Heterogeneous teams allows for differentiation

## Assessments

Completion of design
Completion of design matrix
Teacher observation of group work

## Section II: STEM Lesson Plan

**Title of Lesson** — **Lesson 7: Building the Lunchbox of the Future**

Time Required — 50 minutes

Materials

Materials tested in Lesson 3. Choice and quantities of materials should be determined based on student designs from Lesson 6:
-Styrofoam cups
-Cotton balls
-Plastic wrap
-Copy paper
-Aluminum foil
-Various types of fabric
-Craft sticks
-Bubble wrap
-Cardboard
-Packing peanuts
Student provided boxes (shoe boxes, etc., 1 per team)
Glue (liquid or glue sticks, 5-10 per class)
Tape (masking, packing, and/or duct, 1 roll per team)
Rulers (1 per team)
Scissors (2 per team)
Drawing paper (if needed for sketches)
Team design created on Day 6

Objectives

Students will follow a written/sketched plan to collaboratively create a lunchbox, making design modifications as needed. Students will follow agreed upon roles and responsibilities throughout the process.

Instructional Process

Lesson Preparation:
1. Use the student team designs to determine which materials to gather and how much will be needed. Gather all the materials needed for students to build their lunchboxes.

2. Plan for material distribution. One option is setting up a table with all the materials available. The "Materials Science Engineer" for each team will be responsible for gathering all the materials for their team, which will limit the traffic around the distribution center.

Instructional Process:
1. Review with the class the engineering design process. Note:
a) They have identified the PROBLEM of improving a lunchbox to keep hot foods hot and cold foods cold.

b) During the QUESTION phase, they took a survey about what lunchbox users want and need. They took measurements to determine what size everything needs to be. They tested different materials

c) During the THINK phase, they brainstormed ideas individually, discussed them as a group, and used the design selection matrix to identify the strengths and weaknesses of each idea.

d) The DESIGN phase began when the team chose the best idea. Drawing the sketch and listing the materials was the first step. Now it is time to build the prototype. After building the lunchboxes, we will move into the TEST phase tomorrow. Discuss that there may be times where teams need to weigh the opportunity cost of one material or another once the construction begins.

2. Have teams get out their design sketches/plans. Have the Materials Science Engineer for each team collect the materials chosen by the team.

3. Allow students the full class period to work on assembling their lunchbox. Provide assistance as needed, but refrain from leading students too much. Use questioning techniques to assist students in solving the problems that arise during their building phase.

4. Collect the lunchboxes and store them in a safe place for testing. If a few students need more time, allow them to use free time to work on completing their lunchbox. If the whole class needs more time, allow additional time before the testing lesson.

## Differentiation

Post design requirements for visual learners.
Heterogeneous teams allows for differentiation

## Assessments

Observation of student work. Comparison of student-built lunchboxes to design sketches.

## Section II: STEM Lesson Plan

**Title of Lesson** — **Lesson 8:Testing and Marketing**

**Time Required** — 50 minutes

**Materials**

Student-built lunchboxes (completed in Lesson 7)
Scales (1 per team)
Thermometers (2 per team)
Utility knife (1 per class, to be used by the teacher only)
Plastic storage container (2 per team)
Hot water (around 65 degrees Celsius, 1 cup per team)
Cold water (around 5 degrees Celsius, 1 cup per team)
Appendix L: Performance Assessment Checklist (1 per team)
Appendix M: Performance Assessment Rubric (1 per student for teacher notes)
Appendix N: Design Test Data Sheet (1 per team)
Appendix O: Marketing guide (1 per team)
Red and blue pens OR colored pencils (1 each per team)

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**Objectives**

Students will collect accurate data using tools, graph the data, and analyze the results. Students will create a marketing strategy to "sell" their lunchbox to their classmates.

**Instructional Process**

Lesson Preparation:
1. Gather the materials required for testing the student-built lunchboxes.

2. Copy the data collection sheets and marketing guides for this lesson for each team.

3. Plan for enough hot (not boiling) and cold (not frozen) water for testing.

4. Using a utility knife, cut a small X in the lid of each plastic storage container to be used for testing. This X should be just large enough to allow the thermometer to slide easily into the container.

5. Using a utility knife, cut 2 larger Xs in the lid of the student-built lunchboxes over the space where the plastic containers will sit. The Xs in both the lunchbox lid and the container lid should line up to allow the thermometer to slide through both holes into the water.

6. Practice how to get the thermometer through both Xs and into the water to ease demonstrating this for students.

Instructional Process:
1. Redistribute the lunchboxes and scales to each team. Have each team weigh their lunchbox and write the mass of their lunchbox on their data collection sheet.

2. Explain the data collection procedure:

a) The teacher will fill the containers with hot and cold water and the Materials Science Engineers will collect them from the teacher.

b) The plastic containers will be placed inside the lunchbox with one container in each section of the lunchbox.

c) The Process Engineer will slide the thermometers into the containers and wait two minutes to take an initial reading. Explain that the thermometers will slide through the Xs on the tops of the lunchboxes and into the containers with hot and cold water. Demonstrate how this is done.

d) The teacher will announce when temperature readings will be taken (at 0, 10, 20, and 30 minutes). The Data Engineer for each team will read the temperature on both thermometers and record the temperature on the data collection sheet.

e)The Design Engineer will use the temperature readings to fill in a line graph with the data using a blue and red pen or colored pencil. The “hot” temperature will be recorded in red and the “cold” temperature will be recorded in blue.

3. Explain that while the teams wait between temperature checks, they will begin discussing how to “market” their lunchbox. Explain that marketing is a way to convince others to buy their product and discuss the categories on the marketing guide.

4. Have students insert their thermometers into their containers. Wait about two minutes for the thermometers to adjust to the temperature of the liquids. Have all teams take an initial temperature reading.

5. Repeat at 10, 20, and 30 minutes.

6. Meanwhile, assist teams with their marketing guide and data collection sheets.

7. After the final reading (30 minutes), explain that they are going to use their line graphs to predict the temperatures after 3 hours. Using a ruler, the Data Engineer will extend the line from 0:20 to 0:30, and then to the dark line marked 3:00. Record the predicted final temperature.

8. With whatever time is remaining in the lesson, allow students to continue working on the items in their marketing guide:

a) Teams should come up with a brand name for their lunchbox.

b) Teams should decide how to decorate their lunchbox based on their target customer (boys/girls, age, etc.)

c) Teams should decide on a presentation method (make a commercial, write a song/jingle, etc.).

9. Have students test common lunch items to see how much they can fit inside the lunchbox and determine the total cost of their prototype.

## Differentiation

Students may use digital thermometers.
Rather than cutting holes in the lids, students may take an initial temperature reading, close the containers, and wait 30 minutes. Then take a final temperature reading.

## Assessments

Data collection sheets
Teacher observations
Appendix M: Performance Assessment Rubric

## Section II: STEM Lesson Plan

**Title of Lesson** — **Lesson 9:Redesigning the Lunchbox of the Future**

**Time Required** — 50 minutes

**Materials**

Appendix P: Prototype Analysis and Reflection worksheet (1 per student)
Paper for sketching (as needed)

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**Objectives**

Students will identify the successes and failures of their team's design and develop changes to their design to improve upon it.

**Instructional Process**

Lesson Preparation:
1. Make copies of the Prototype Analysis and Reflection worksheet (Appendix P)

Instructional Process:
1. Pass out the Prototype Analysis and Reflection worksheet to each student.

2. Have students sit together with their teams.

3. Instruct the students to individually complete the first two questions on the Prototype Analysis and Reflection worksheet. Once everyone in their team is finished with these sections, teams are to discuss amongst themselves what successes and failures they found with their designs.

4. After this discussion, teams are to then come up with ways to improve upon their design. Have students write down these ideas in the last section of the Prototype Analysis and Reflection worksheet.

5. Based on the teams' discussions, have the Design Engineer from each team create a sketch of their team's "new and improved" lunchbox design with explanations of their changes to their designs.

**Differentiation**

Heterogeneous teams allows for differentiation

**Assessments**

Completion of Prototype Analysis worksheet
Production of teams' new designs
Teacher observation

## Section II: STEM Lesson Plan

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|---|---|
| **Title of Lesson** | **Lesson 10: Preparation for Presentations** |
| Time Required | 50 minutes |
| Materials | Art supplies (class set)<br>Appendix O: Marketing Guide (1 per student) |

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**Objectives**

Students will prepare a presentation of their lunchbox design that they believe will best appeal to their target demographic.

**Instructional Process**

Lesson Preparation:
1. Collect any art supplies the class may need in order to decorate their lunchboxes or prepare presentations for their designs.

Instructional Process:
1. Explain to the class that they are the entrepreneurs and producers of their product (the lunchbox) and that they must develop their product with their consumers in mind. They want to produce a product that their consumers will want to buy and out-sell their competition. Explain that the consumer of their product is anyone who will be buying and using their lunchbox.

2. Students will use this class period to develop a marketing presentation using the Marketing Guide to ensure that they are meeting all points of the presentation. For this, students will have to:
a) Decide on a brand name for their lunchbox.
b) Plan who they will market their product to (boy, girls, both, people of a certain age), and how they will go about marketing the product effectively to that demographic.
c) Describe how they will decorate their lunchbox and provide reasons for their choices.
d) Create a commercial, jingle, etc. to “sell” their product to their consumers.

3. Teams can use any medium for their presentation that they deem fit (posterboard, jingle, commercial, video, dance, etc.) Stress that the more original their marketing plan, the more likely it will appeal to their consumers, and the better their product appeals to their consumer, the more likely it is to out-sell the competition.

**Differentiation**

Heterogeneous teams allows for differentiation

**Assessments**

Completion of marketing plan
Teacher observation

## Section II: STEM Lesson Plan

**Title of Lesson**

**Lesson 11:Presentations/ Post-test/ Peer Reviews**

Time Required

50 minutes

Materials

Appendix A: Post-Test (1 per student)
Appendix M: Performance Assessment Rubric (1 per student)
Appendix R: Peer Reviews (half sheet per student)

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Objectives

Students will present their lunchboxes to the class. Students will complete the post-test and peer reviews.

Instructional Process

Lesson Preparation:

1. Make copies of Appendices A, M, and R.

Lesson Process:

1. Begin class presentations. Score each group's presentation according to the Performance Assessment Rubric.

2. Optional- Allow students at their seats to evaluate the presentations by writing their comments on sticky notes and then putting them on the teams' desks when all presentations are done. If students do this, it may be helpful to have a conversation about how to write constructive comments.

3. After all presentations are finished, collect any remaining data sheets from students and administer the post-test.

4. When post-tests are completed pass out Peer Reviews. Then collect when complete.

Differentiation

Read items aloud for students with difficulty reading the questions on the post-test or peer review.

Assessments

Presentations

Post-test

## Section III: Unit Resources

### Materials and Resource Master List

Art supplies (class set)

Boxes (student provided; shoe box sized, etc., 1 per team)

Bread slices (at least 1 per team)

Calculators (1 per student)

Chart paper and markers (optional)

Freezer

Glue (liquid or glue sticks, 5-10 per class)

Ice (several trays of ice cubes at various points in the unit)

Juice Boxes, not for consumption (at least 1 per team)

Paper cups, approximately 12 oz. (1 per team)

Pens OR colored pencils (red and blue; 1 each per team)

Plastic cups, approximately 12 oz. (1 per team)

Plastic storage container, 1-2 cup size (2 per team)

Printable Resources document

Resealable plastic sandwich bags (Sandwich size; 3-5 per team)

Rulers (1 per student)

Scale, accurate to nearest gram (1 per team)

Scissors (2 per team)

Sticky notes (10-15 per student)

Stopwatch OR online timer (1 per team)

Styrofoam Cups, approximately 12 oz. (1 per team)

Student lunchboxes (1 per team)

Tape (masking, packing, and/or duct, 1 roll per team)

Thermometers (3 per team)

Utility knife (1 per class, to be used by the teacher only)

Various other typical lunch items (at least 1 of each per team)

Water

Insulation materials (for the class): (These are suggestions and not limited to the following. These are rough estimates of amounts of materials and may need to be changed based on the size of the class)

Aluminum foil (100-200 square feet/1-2 rolls)

Bubble wrap (50-100 feet/1 roll)

Cardboard (20-40 6"x6" squares -- use empty boxes, etc. as source material)

Cotton balls (200-600 jumbo cotton balls/1-3 bags)

Napkins, paper (1 package)

Packing peanuts (1-2 cubic feet/1 bag)

Paper (1 ream)

Plastic wrap (100-200 square feet/1-2 rolls)

Styrofoam cups (100 - any size)

Various types of fabric (1 yard each) (fleece, wool, etc.)

Wood craft sticks (200 - any size)

## Key Vocabulary

Area- the space a two dimensional shape takes up; length multiplied by width (for a rectangle) (Area, 2013)

Budget- plan to help people make economic decisions for the present and future (Ohio Department of Education, 2011)

Celsius- temperature scale used in the metric system and in other countries around the world; °C

Cold- something that has a low temperature; the absence of heat

Conduction- the transfer of heat energy between two objects that are touching each other from the hotter material to the cooler material (HowStuffWorks.com, 2009)

Consumer- a person whose wants are satisfied by goods and services (Ohio Department of Education, 2011)

Convection- the transfer of heat energy through a liquid or gas (HowStuffWorks.com, 2009)

Data- a list of observations, measurements, and facts that can be studied (Data, 2013)

Entrepreneur- a person who organizes productive resources and take risks to make a profit and compete with other producers (Ohio Department of Education, 2013)

Fahrenheit- temperature scale used commonly used in the U.S.; °F

Gas- substance that fills the volume and shape of its container

Heat- a form of energy that causes solids, liquids, and gases to become warmer (Merriam-Webster: Learner's Dictionary, 2013)

Hot- something that has a high temperature; the presence of heat

Insulator- a solid, liquid, or gas that slows the transfer of heat (or other energy) from one object to another (Kurtus, 2006)

Liquid- substance that has constant volume and fits the shape of its container

Market- where buyers and sellers exchange goods and services (Ohio Department of Education, 2011)

Mass- the quantity of matter in something; mass does not change (Mass, 2013)

Matter- a substance that occupies space and has mass (Matter, 2013)

Opportunity Cost- the value of the next best alternative given up when an economic choice is made (Ohio Department of Education, 2011)

Perimeter- the outside edge of a surface (Perimeter, 2013)

Producer- makes goods and/or provides services (Ohio Department of Education, 2011)

Prototype- a first model of a design (Prototype, 2013)

Radiation- the transfer of heat energy in the form of waves (HowStuffWorks.com, 2009)

Scarcity- the concept that resources are limited and there will not always be enough of something for everyone

Solid- object with a constant volume and shape

Temperature- the measure of amount of hot or cold (HowStuffWorks.com, 2009)

Volume- the amount of space that an object or substance occupies; measured in cubic units (Volume, 2013)

## Technical Brief

Heat and Thermal Energy

Heat is a form of energy called thermal energy. Specifically, heat is the energy possessed by the motion of molecules in solids, liquids, and gases (HowStuffWorks.com, 2009). When the molecules in a solid, liquid, or gas are disrupted and start to move, heat is created. One common unit of heat is the calorie which is defined as "the amount of heat required to raise the temperature of one gram of water one degree Celsius" (The Engineering Toolbox, n.d.). This is not the same as a dietary Calorie, which is usually capitalized because a Calorie is measured in kilocalories, or 1000 calories (Calorie, 2013). One calorie (lower case c) is equivalent to 4.184 Joules which is another way to interpret heat energy (Calorie, 2013). Temperature, on the other hand, is not a unit of heat; however, it is the measure of intensity of hot or cold. A more specific definition of temperature is "the ability of one body to give up heat energy to another body" (HowStuffWorks.com, 2009), which is measured using a thermometer in the Fahrenheit, Celsius, and Kelvin scales.

Heat is transferred in three different ways: conduction, convection, and radiation. Conduction is the transfer of heat when a hotter material and a cooler material are in contact with each other (HowStuffWorks.com, 2009). As the second law of thermodynamics states, the molecules of the hotter material transfer their energy to the molecules of the colder material (HowStuffWorks.com, 2009). Therefore, the heat seems to "flow" from the hotter material to the colder material through conduction. For example, if you put a pot on the stove, the heat is conducted from the coils of the stove to the metal of the pot.

Convection is another way in which energy is transferred. Convection is the transfer of energy through a fluid (a liquid or gas) (HowStuffWorks.com, 2009). For example, a hot air balloon is an example of convection. The heat source heats up the air near it. That air rises to the top of the balloon, and the cooler air sinks down to the heat source, and the process continues. Through convection, heat is distributed throughout the fluid. Convection ovens are another example of this kind of transfer of energy. These ovens contain a fan to evenly distribute the heat of the oven and circulating the hot air. This makes for better cooking because the heat is evenly distributed (Devries, 2013).

Radiation is the release of electromagnetic waves. "All bodies continually give off energy in the form of rays" (HowStuffWorks.com, 2009). These bodies emit rays from the movement of the molecules. For example, a fire and even a light bulb give off radiation in the form of heat waves. When you have a fire in the fireplace of your house, the radiation from the flames and coals heat the surrounding objects in the room, not the air in the room; the air that is heated by the fire goes up the chimney (Thermal Radiation, 2013). The Sun's heating of the Earth and microwave ovens heating up your food are other examples of radiation.

Heat can have a great effect on many substances and materials in our world. Heat is what changes matter into different states. Solids, objects with definite volume and definite shape, can be heated to change its state into a liquid.  Liquids, which have definite volume and take the shape of their container, can be heated to change its state into a gas.  Gases fill the volume of their container and take the shape of their container.

Although heat can be transferred in many ways and affect different states of matter, heat can also be contained. This containment is called insulation.  An insulator is a material or fluid that reduces the transfer of heat from one object or fluid to another. Specifically, a good insulator is something that is a poor conductor of heat because it prevents heat from being transferred easily (Kurtus, 2006).  Materials that are less dense are better insulators than more dense ones (Kurtus, 2006).  This is because the molecules are farther apart which keep the surrounding molecules from get agitated, thus minimizing heat flow.  In addition, good insulators are poor conductors of electricity (Kurtus, 2006) because they limit the flow of electrons, which in turn, limit the flow of energy.  There are many examples of insulators in our world today.  One example of insulating from conduction is wearing clothes in the winter time.  Another example would be the vacuum that is present in a thermos (Kurtus, 2006).  To insulate from convection, one would wear protective clothing on a windy day to prevent the cold air from drawing the heat from you thus making you cold.  Heat by radiation can also be insulated. Insulation of radiation is usually done by using reflective materials.  This is why you put a reflective cover over your windshield on a hot summer day to keep your steering wheel from becoming too hot.  Insulation is measured using an R-value (Kurtus, 2006).  This value demonstrates the material's resistance to heat flow.  It is used to tell how good of an insulator a certain material will be.  The better insulator has the higher R-value (Kurtus, 2006).

## Safety and Disposal

Do not eat any of the materials of any of the experiments

The melting ice cubes may make the floor wet.  Be careful to not slip.  Clean up the water as soon as possible. The plastic bags should remain closed in order to minimize this risk.

When measuring food items, the bags should be kept closed to limit spill and to keep the students from eating the foods.

Care should be taken when using scissors.  Teacher supervision is required.

Materials should not be placed in your mouth.

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# Section IV: Appendices

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