**Sustainable Lunchrooms**

Grade Level(s): 9, 11-12 Subject(s): Chemistry, physical science, Environmental Science

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**Problem Statement:**

School lunches and food are a part of everyday life for high school students, something that is often taken for granted. Knowing the enormous amounts of energy that food production and service requires, how can the lunchroom be made more sustainable?

**Conceptual Storyline:**

Students will develop an understanding of sustainability and explore opportunities to reduce human impacts to conserve energy and resources. The problem we will pose to students is that they must redesign a school lunch that is more sustainable than a current option. In order to address this, students will determine criteria for ‘sustainability,’ interview food services staff, analyze current school lunch options, research new options, and propose a new lunch based on established criteria. Students will display an infographic that presents their findings related to sustainability. Students will then evaluate the presented options and determine, based on the criteria and the use of a Pugh chart decision-making tool, which group’s is the most sustainable. Students will be engaging in argument from evidence, analyzing and interpreting data, evaluating and communicating data and constructing explanations and designing solutions.

**Standards (NGSS, CCSS, CTE):**

* HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
* HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
* HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.\*
* HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.\*
* HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**21st Century Skills:**

Students will be expected to communicate with other students through group work, operate as a team in creating their infographic, problem solve and think critically about other potential solutions, and demonstrate professionalism through their final product and presentation.

**Locally and/or Personally Relevant for Students:**

By sharing data collected and ideas for solutions with other teams, students will build on their understanding of the underlying problem and need for improvement within their school. Since students often have some say in what food they purchase at school or what their parents purchase at home, this unit will allow them to feel empowered to make choices that will have a positive impact on sustainability.

**Table of Content/Overview of Unit**

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Lesson 5: Presentation of Infographics

Lesson 6: Best Solutions Discussion

Supplemental Lesson: Bag It – Is your life too plastic?

Supplemental Lesson: Polymers and Plastics

Supplemental Lesson: Life Cycle Analysis

**Lesson 1 Energy Use in Everyday Life**

**Problem Statement:** How can school lunches be modified to require less energy? This lesson introduces students to the idea of the carbon footprint: that all daily activities require energy and contribute to carbon dioxide to the atmosphere. Students will consider school lunches as one component of energy usage that they can have an impact on.

**Learning Objectives:**

Students will be to:

* Demonstrate understanding of activities that contribute carbon dioxide to the atmosphere as part of their carbon footprint
* Identify factors that can be changed to reduce their carbon footprint
* Describe why it may be important to reduce their contribution.

**Materials:** Laptops or iPads (one per student), PowerPoint

**Lesson Preparation:** Be sure that the Carbon Footprint website will load on the device that students will be using.

**Time Required: at least** 50 minutes

**Procedure:**

**Introduction:**

Students will be presented with warm up questions (in PowerPoint) that asks them to:

1. List at least 10 activities you do on a daily basis that require energy.
2. Of all the things in your list above, which do you think uses the most energy overall? Explain.
3. Where do we get the energy we need to accomplish these tasks? Describe in as much detail as you can.

**Explore the Problem:**

What is an ecological footprint?

*The ecological footprint measures how fast we consume resources and generate waste compared to how fast nature can absorb waste and generate new resources.*

Students will be introduced to the term ‘Carbon footprint’ and given time in class to calculate their own carbon footprint using the following website:

<http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/>

**Evaluating the Process:**

Construct a table of how many earths are needed if all people had the ecological footprint of your students. Students should discuss:

**Lifestyle choices**

1. What choices result in the largest carbon footprint?
2. What is the role of diet: food-miles, relative impact of red meat, other meat, dairy, and all other foods?
3. Which portions of the carbon footprint do students personally control, vs. their parents, vs. broader society?

**Process**

1. What was difficult?
2. What assumptions did we have to make?
3. Do you think these values include the entire life cycle analysis?
4. What causes the differences between the by hand and online tool?

**Implications for the Future:**

**Lifestyle choices**

1. How do you and your classmates compare to the rest of the US? Europe?  The world?
2. What choices result in the largest carbon footprint?
3. What is the role of diet: food-miles, relative impact of red meat, other meat, dairy, and all other foods?
4. Which portions of the carbon footprint do students personally control, vs. their parents, vs. broader society?
5. What can students change?

**Conclusion:**

The class will discuss the results and discuss which components of their carbon footprint are within their control as teenagers.

* As teenagers, which contributors to the carbon footprint can you control?
* Which contributors can you not control?

**Homework:**

Students are asked to brainstorm a list of at least 10 aspects of school lunches that factor into their energy usage.

**Assessment:**

Formative: Warm up questions, discussion of results of carbon footprint activity, homework

Summative: None for this introductory lesson

**Accommodations:** For students who do not have iPads or access to a laptop, you can provide them a paper copy of a similar carbon footprint activity which gives results in the same units. Paper found here: (Attached PDF)

**Extensions:** With additional time, go into further detail in the discussion of contributing factors to their carbon footprint. After discussion, students can go back into their carbon footprint calculation and make changes to determine the impact of the changes.

**References/Resources:**

Questions, prompts, definitions: PowerPoint

Carbon footprint calculation:<http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/>

**Websites and articles below**

**Food Waste:**

Short article on reducing food waste at home

<http://www.npr.org/blogs/thesalt/2014/11/17/364172105/to-end-food-waste-change-needs-to-begin-at-home>

Very long article with multiple suggestions for how to improve sustainability of food system, good section on Food Waste

<http://www.sustainableamerica.org/blog/how-to-make-the-food-system-more-energy-efficient/>

**Food Choices:**

Short article on choosing more sustainable food products (insects)

<http://www.npr.org/blogs/thesalt/2013/05/13/183676929/maybe-its-time-to-swap-burgers-for-bugs-says-u-n>

Short article on GHG emissions from beef and guidelines that may suggest less red meat

<http://www.bellinghamherald.com/2015/01/02/4057246_next-government-food-guidelines.html?rh=1>

Really long pdf on school lunches, but has lots of really good facts to harvest

<http://www.ecoliteracy.org/sites/default/files/uploads/rethinking_school_lunch_guide.pdf>

Short article on sustainability in school lunches in one particular district

<http://www.huffingtonpost.com/leah-mayor/sustainable-school-food-green_b_842816.html>

**Energy Use of Food Production:**

Long report with helpful statistics on energy use of food production

<http://www.cias.wisc.edu/wp-content/uploads/2008/07/energyuse.pdf>

Infographic on problems with current food system

<http://hydro-logic.blogspot.com/2012/09/monday-infographics-food-security.html>

Short article on changes in American diet and energy usage

<http://blogs.scientificamerican.com/plugged-in/2011/08/11/10-calories-in-1-calorie-out-the-energy-we-spend-on-food/>

List of helpful statistics on American food system

<http://css.snre.umich.edu/css_doc/CSS01-06.pdf>

**Food Miles and Sustainability:**

NY Times article that discusses research indicating local is not necessarily more sustainable

<http://www.nytimes.com/2007/08/06/opinion/06mcwilliams.html>

**Lesson 2: Sustainability:  Environment, Society and Economy**

**Problem Statement:**School lunches and food are a part of everyday life for high school students, something that is often taken for granted. Knowing the enormous amounts of energy that food production and service requires, how can the lunchroom be made more sustainable?

**Learning Objectives:**

Students will be able to

* Define sustainability, identify issues they believe are important for future generations
* Identify factors or issues that need to change in order to ensure a better future and explain how sustainability issues relate to the environment, society and the economy
* Determine what items make up the majority of our cafeteria’s trash
* Determine what can be done to minimize the impact to the environment
* Use a Pugh Chart to evaluate multiple solutions to determine the best one

**Materials:** PowerPoint, Pugh Chart Excel file, white boards

**Lesson Preparation:**Review PowerPoint file, Pugh Chart Excel file

**Time Required:** Two 50 minute periods

**Procedure:**

**Introduction:**

Define sustainability then describe links between economics, environment and society. What materials or practices do you want to pass down to your children? List student ideas on the board. What events or practices need to change to make the future more sustainable? How does this relate to making a more sustainable school lunch program?

Discuss definition of sustainability and Venn diagram

(Use Thwink.org/sustain/glossary/environmental sustainability.htm)

**Exploration:**

**Observations**

1. What are the sources of waste?
2. What makes up the majority of waste?
3. What in the garbage does the most harm to the environment?
4. Can packaging be improved or minimized?
5. Why might some food be thrown away?
6. What can be done to minimize how much food is thrown away?

**Current Cafeteria Practices**

1. What types of foods are served in the cafeteria?
2. Where do these foods come from?
3. How are these foods prepared?
4. What are the energy inputs and outputs of the process?
5. What materials are used and disposed of?

**Explain: What is a Pugh Chart**?

A Pugh chart is a simple design tool for weighin design ideas against your design criteria early in the design process.

1. List the design criteria in the left column.
2. Weigh each criterion according to how important it is.
3. List the possibilities across the top.
4. Score each possibility by multiplying the score by the weight.
5. Add the points for all possibilities to determine the best project.

**Sample Problem: What is the best way to get to Northgate Mall?**

Students will work in groups of 3 or 4 to create a criteria and criteria weights for the Northgate Mall scenario.

1. List the possible modes of transportation to Northgate.
2. What criteria would you use in choosing the best possible way to get to Northgate Mall? Make a list.
3. Given 100 points, assign points to each criteria based on its importance in making a good decision.
4. Discuss student point distribution.
5. Collect and average the points for each criteria to create a weight system for the Pugh Chart.
6. Use the point weights to evaluate the possible ways of getting to Northgate Mall.

**What criteria would you use to select a sustainable cafeteria solution?**

Students will work in groups of 3 or 4 to create a criteria and criteria weights for the Northgate Mall scenario.

1. List the possible criteria for selecting a sustainable cafeteria design. Write these criteria on the board.
2. Within your group, distribute 100 points to each criteria based on its importance.
3. Collect and average the points from each group to create the weights for each criteria.

These criteria and criteria weights will be used to evaluate your final project.

**Elaborate: Creating your proposal**

1. Write your possible projects across the top of the Pugh chart.
2. Score each possibility to determine your project topic. (Score -2 to 2 with 2 being the highest score)
3. Multiply the score by the class weight score.
4. Add down the point column to determine the final points for each possible project.
5. Write a research questions.
6. Define your criteria and constraints.

**Conclusion:**

Discuss the significance of the interconnectedness of sustainability issues and why it might be helpful to understand how and why these issues are interconnected, and how understanding the interconnectedness of sustainability issues can help us find solutions to the problems surrounding these issues.

**Homework assignment**: Watch the lunchroom, with the idea of identifying sustainability issues. Write your observations in your notebook.

**Assessment:**

 Formative – completion of group activity

 Summative – completion of homework assignment

**Accommodations:** Students with visual impairment will need assistance during the yarn ball exercise

**Extensions:** Find other sustainability definitions and compare them.  Create a class definition     

**References/Resources**: Venn diagram and definition of environmental sustainability:  Thwink.org, Poster

**Lesson 3: Developing an Argument for Change**

**Problem Statement:** How can school lunches be modified to require less energy? This lesson guides students to finding sources of data that could help to support their proposed solution. Students will be encouraged to find existing data, and collect their own data, if possible.

**Learning Objectives:** Students will demonstrate understanding of how to collect valid and reliable data, and their ability to find credible existing resources.

**Materials:** Laptops or iPads (one per student or at least one per group), PowerPoint

**Lesson Preparation:** Find websites that might hold information students can use. Have the name(s) of district employees in charge of food service available for students to email, or plan to create one email with questions that arise. Make sure computers are available and charged.

**Time Required:**  Three 50 minute periods

**Procedure:**

**Introduction:**

If you wanted to provide evidence that your solution is accurate, how would you collect data? Brainstorm at least 3 sources of data that you could find or collect to support your solution.

**Exploration**

Students will be led in a discussion to explore the types of data that could be helpful for supporting that their solution will increase the sustainability of school lunches. The discussion will focus on the following prompts:

1. What type of data is most convincing to the general public?
2. What type of data is most convincing to scientists?
3. What do the terms reliable, valid and credible mean?
4. How can we collect reliable and valid data?
5. Where could we find credible data?
6. What keywords from your problem or solution could you use to search?
7. Is there a way to put together your data in a way that leads the audience to the conclusion you would like them to come to?

Students will be given time to plan their data collection methods with their group.  They will be directed to the rubric for the infographic to guide their selection.

**Conclusion**

Write down your assignment from your group. Remember that it is your responsibility to complete the task and communicate your progress with your group members.

Answer the following prompts tonight

1. Today I learned that…
2. An important idea to think about is…
3. Something that I don’t completely understand yet is…
4. Something that I’m really confident that I understand is…

**Homework:**

Students will be expected to collect their data before the rough draft of the infographic is due.

**Assessment:**

Formative: Warm up questions, class discussion of data, share out of plan for data collection

Summative: None for this lesson

**Accommodations:**

For students who do not have iPads or access to a laptop, they can work with a group member to find credible data.

**Extensions:**

With additional time, go into further detail about sources of data for scientific purposes.  Discuss peer-reviewed literature, and have the librarian come into class to discuss databases available to the school.

**References/Resources:**

Warm up questions and prompts: PowerPoint attached.

**Lesson 4: Infographics as a Presentation Strategy**

**Problem Statement:**

How can we make our school cafeteria function in a more sustainable, less energy-using way?  This lesson introduces students to infographics as a way to communicate their solution to the problem in a visually interesting format, as they explain the merits of their solution to their classmates.  During the presentation of the infographics, each student will be taking data on the solutions which they will then use to evaluate the solutions based on a Pugh chart of criteria they have previously created and weighted.

**Learning Objectives:**

Students will be prepared to:

* Learn how to communicate a message through infographics.
* Explain their cafeteria solutions by presenting data using graphs and statistics.
* Argue their case for change using an infographic and numbers to convince the audience.
* Apply their own weighted criteria to each one to make decisions about what constitutes the “best” solution.

**Materials:**

Access to computers that will run the “PiktoChart” website to create infographics, computer access to a projector that will show infographics, in-class data sheet, Pugh Chart (Homework)

**Lesson Preparation:**

Previous lessons accomplished.

Practice PiktoChart facility prior to introducing the site to students.  Check computer to projector compatibility to show PowerPoint.

Photocopy (reformat as needed) in-class data sheets

Have extra Pugh Charts as needed (students should already have them)

**Time Required:** Three 50 minute periods  
  
**Procedure:**

**Introduction: What is an infographic**?

Students will review an infographic and answer some discussion questions about the information presented.

1. What is the first impression of the graphic? What do you know about the topic in the first 5 seconds of looking at it?
2. What are some of the details or facts you can learn from the graphic?
3. What are details not included on the graphic? What could be added to it?
4. Is the graphic intended to make you think about an issue, take a stand, or change your behavior? If so, is it effective?

**Explore: Sample Infographics (PowerPoint)**

**Sample 1: Water Bottles**

Question: How are water bottles recycled?

Research:

* How many water bottles are use daily?
* How are these bottles recycled?
* What is the process used to prepare them for a new application?

**Sample 2: Recycling**

Question: Who profits from recycling?

Research:

* How much money do business spend on waste disposal?
* Who uses the recycled materials?
* How much money is required to recycle materials?
* How much money is spent on waste disposal?
* How does the environment benefit?

**Sample 3: The Coffee Cup**

Question: What is the impact of buying Starbucks each day?

Research:

* How many cups would this represent in one year? 10 years?
* If everyone at school did this?
* How many people in the US buy coffee daily?
* What is the cost?
* What materials and energy is required to make a cup?
* How many trees does this represent?
* How much trash?
* What are the alternatives?

**Sample 4: Food Waste**

Question: What is the cost of unused food?

Research:

* What are the most common foods not eaten?
* How much food is wasted each day in the cafeteria?
* How often do people buy food that they do not eat?
* How do people dispose of uneaten food?

**Generic Questions for Groups**

In your group, analyze the infographic and answer the questions.

1. What is the title of the infographic?
2. What are the features of each infographic?
3. What types of artwork is present?
4. How is the artwork connected to the message?
5. How is data presented?
6. How is the data used to support the message?
7. In your own words, what is the infographic telling you?

**Explain: Processing your research using PiktoChart**

Have them find the PiktoChart website and follow along as teacher leads them through the basic application of the site.  Remind them they don’t have to pay or sign up!  This limits them somewhat (also a reminder!!)  The block period is then dedicated to the creation of the infographic.  As they finish the product, it can be sent in whatever manner is best for the electronic nature of the school to the teacher.  All infographics should be in the teacher’s possession before they are shown to the class.

1. Step 1: Research Question
2. Step 2: Brainstorm Ideas
3. Step 3: Research/Data Collection and Analysis
4. Step 4: Infographic Study

**Conclusion: Reflection.**

The 50 minute period will be used to present up to 8 infographics.  Each group will have up to but no more than 5 minutes to present and entertain questions.  The presentations should be no more than 3 minutes so there is time for student questions.  Groups should practice!!  Teacher could require notecards to be turned in as evidence of rehearsal after the presentation.  Students will fill out the data sheets as presentations are done.

**Homework:**  Students will complete their Pugh Charts based on the data gathered during the presentations.  These will be used by students as they participate in the Socratic Seminar, so they should be due before that event occurs.

**Assessment:**

Formative:  completion of the infographic, successful data collection from other students.

Summative:  Completion of the Pugh Chart from data collected in the infographics class session - homework

**Accommodations:**

Visual impairment:  Splashtop, which will allow students to display projected images onto their iPads or laptops and allow them to enlarge the images as needed.

Auditory:  classroom microphone system

**Extensions:**

Allow students’ time to interview each other individually and ask further clarifying questions.  Write the transcript of the interview.  Perhaps assign a short essay comparing one other solution to one’s own based on the interview and Pugh Chart.

**References/Resources:**

A  Student data-gathering sheet (Re-format as needed)

B  Pugh Chart

C  PowerPoint

**Lesson 5: Presentation of Infographics**

**Problem Statement:**

How can we make our school cafeteria function in a more sustainable, less energy-using way?

**Learning Objectives:**

Students will be prepared to:

* Present their infographic in front of the class
* Entertain questions on their data and findings
* Assess the solutions to the problem using the Pugh chart

**Procedure:**

The 50-minute period will be used to present up to 8 infographics.  Each group will have up to but no more than 5 minutes to present and entertain questions.  The presentations should be no more than 3 minutes so there is time for student questions.  Groups should practice!!  Teacher could require notecards to be turned in as evidence of rehearsal after the presentation.  Students will fill out the data sheets as presentations are done.

**Homework:**

Students will complete their Pugh Charts based on the data gathered during the presentations.  These will be used by students as they participate in the Socratic Seminar, so they should be due before that event occurs.

**Assessment:**

Formative:  successful data collection from other students.

Summative:  Completion of the Pugh Chart from data collected in class - homework

**Accommodations:**

Visual impairment:  Splashtop, which will allow students to display projected images onto their ipads or laptops and allow them to enlarge the images as needed.

Auditory:  classroom microphone system

**Extensions:**

Allow students’ time to interview each other individually and ask further clarifying questions.  Write the transcript of the interview.  Perhaps assign a short essay comparing one other solution to one’s own based on the interview and Pugh Chart.

**References/Resources:**

A  Student data-gathering sheet

B  Pugh Chart

**IPSH Project: Lunchroom Sustainability, Infographic Rubric**

Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Per: \_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CATEGORY** | **Exceeds Standard**  **(4)** | **Meets Standard**  **(3)** | **Approaches Standard**  **(2)** | **Standard**  **Not Met**  **(1)** |
|
| Explanation of Their Specific Problem | meets criteria for ‘3’ And is especially clear and well-written. | includes explanation of specific component of school lunches that is being addressed. | Explanation is lacking detail. | Explanation is incomplete or missing important detail. |
| Proposed Solution | meets criteria for ‘3’ And solution is especially innovative or creative. | Proposal is complete and clear, And audience understands details of solution. | Does not meet one criterion for a '3.' | Does not meet either criteria for a '3.' |
| Explanation of Solution Based on Class Ideas | meets criteria for ‘3’ And explanation shows in-depth knowledge of energy. | solution is clearly connected to reduction of energy usage or carbon footprint. | Solution is vaguely connected to reduction of energy usage or carbon footprint. | Solution is not connected to reduction of energy usage or carbon footprint. |
| Steps for How It Would Be Achieved | meets criteria for ‘3’ And plan is detailed enough to be implemented by reader. | Plan for enacting solution is complete and detailed. | Does not meet one criterion for a '3.' | Does not meet either criteria for a '3.' |
| Projection of the Impact of Solution (Plausibility, what would you expect to see and how would you measure it?) | meets criteria for ‘3’ And predicted impact is significant. | predicted impact is measurable, realistic and clearly stated. | Does not meet one criterion for a '3.' | Does not meet two or more criteria for a '3.' |
| Pros and Cons of their Solution | meets criteria for ‘3’ And no obvious cons have been omitted. | Multiple, specific pros and cons are listed clearly. | Does not meet one criterion for a '3.' | Does not meet either criteria for a '3.' |
| Data Collection (done by student) (survey, waste stream analysis, packaging analysis, interview) | meets criteria for ‘3’ And collection methods were creative, reliable and valid. | Group displays data collected first-hand, and includes explanation of reliability and validity. | Does not meet one criterion for a '3.' | Does not meet either criteria for a '3.' |
| Data from Outside Sources (credible and more generalized) | meets criteria for ‘3’ And data is presented in a manner that is particularly thorough and convincing. | Presents relevant data from at least 3 credible sources. | Does not use data from 3 sources or sources are not all credible | Does not meet either criteria for a '3.' |
| Diagrams and images | Meets criteria for ‘3’ AND diagrams/images are particularly well chosen and well placed. | Student has utilized diagrams/images in the infographic and the images enhance audience understanding of the proposed solution. | Does not meet one criterion for a '3.' | Does not meet either criteria for a '3.' |
| Organization | Meets criteria for '3' AND infographic is particularly well designed and interesting. | Content is organized in a clear, logical, professional and interesting way. A title is included, as well as the author’s full name. | Does not meet one criterion for a '3.' | Does not meet two or more criteria for a '3.' |
| Conventions | Zero spelling/grammar mistakes. | One or two spelling/grammar mistakes. | Several spelling/ grammar mistakes. | Errors in spelling/ grammar are distracting. |
| Presentation | Meets criteria for ‘3’ And presentation is particularly engaging and convincing. | Presentation is professional, can be heard from the back of the room, and appears rehearsed. | Does not meet one criterion for a '3.' | Does not meet two or more criteria for a '3.' |

**Lesson 6: Best Solutions Discussion**

**Problem Statement:** How can school lunches be modified to require less energy? This lesson introduces students to the idea of the carbon footprint: that all daily activities require energy and contribute to carbon dioxide to the atmosphere. Students will consider school lunches as one component of energy usage that they can have an impact on.

**Learning Objectives:**

Students will be able to:

* Reflect on what they learned about
  + Reducing the ecological footprint through small changes in the school cafeteria.
  + Developing a Pugh chart for evaluating the sustainable solutions presented in their infographic.
  + Communicating the solution to a complex problem through data in a infographic.
  + Evaluating the implications sustainable practice has for the future in terms of life style, education, and careers.

**Materials:** Laptops or iPads (one per student), PowerPoint, Post-Assessment Reflection

**Lesson Preparation:**

1. Summary of Pugh chart results inserted into the presentation.
2. List of project topics with scores.
3. Grouping of projects based on key strategies
   1. changes in food choices
   2. changes to lunch delivery
   3. limitation in packaging
   4. changes in waste sorting/types of waste
   5. reduction in energy

**Time Required:** at least 50 minutes

**Procedure:**

**Engagement:**

1. Project Pugh chart scores
   * What projects demonstrated the greatest impact on reducing energy and materials use?
   * What were the key characteristics of successful projects?

**Exploration: What can we learn from project choices?**

* What were the key strategies used to reduce energy and material use?
* What projects demonstrated the greatest change in energy usage and sustainability?
* For the most promising projects, what steps would need to tak place in in order to implement the change?
* For the most promising projects, what would need to happen to make the changes sustainable over time?

Pugh Chart

* How did you assign values on your Pugh chart?
* What were your key considerations?
* What criteria in your Pugh chart were the most valuable for evaluating sustainability project?
* What criteria were the least valuable in evaluating projects?

**Evaluating the process**

* What were the lessons learned about sustainability?
* How effective was the Pugh Chart in evaluating the success of projects?
* How did the data in the infographic influence your understanding of the project goals?
* What other lessons were learned?
* After reviewing all projects, what would you change?

**Implications for your future**

* What implications will sustainability practice have on your future?
* What future careers will be associated with sustainable practice?
* What new businesses or changes to existing businesses are associated with practicing sustainability?
* Washington Career bridge <http://careerbridge.wa.gov/Search_Occupation.aspx?cmd=txt&adv=true&txt>=

**Evaluation:**

* Post Assessment

**Homework:**

Reflection

**Assessment:**

Post Assessment

**Accommodations:**

Visual impairment: Splashtop, which will allow students to display projected images onto their iPads or laptops and allow them to enlarge the images as needed.

Auditory: classroom microphone system

**Extensions:**

**References/Resources:**

Questions, prompts, definitions: Powerpoint attached

Finding good work and jobs in sustainable agriculture

<https://stockbridge.cns.umass.edu/SFF-good-work>

<http://www.ift.org/knowledge-center/learn-about-food-science/world-without-food-science/sustainability.aspx>

College and Beyond

<https://sustainablefoodjobs.wordpress.com/college-and-beyond/>

Bureau of labor statistics

<http://www.bls.gov/ooh/life-physical-and-social-science/agricultural-and-food-scientists.htm>

**Supplemental Lesson: Bag It – Is your life too plastic?**

**Problem Statement:** How can school lunches be modified to require less energy? This lesson introduces students to the idea of the carbon footprint: that all daily activities require energy and contribute to carbon dioxide to the atmosphere. Students will consider school lunches as one component of energy usage that they can have an impact on.

**Learning Objectives:**

Students will be able to:

* Identify the key issues related to plastic production and use.
* Discuss issues related to waste and recycling.
* Explain the how plastics are accumulating in the ocean.
* Explain how plastics are effecting the food chain and species diversity.
* Explain which plastics may have adverse effects on human health.

**Materials:** bag it – Is your life too plastic DVD by Suzan Beraza, DVD Player, Bag it – Discussion questions worksheet and PowerPoint as well as Demonstration materials: 1 M HCl, aluminum soda can, beakers, steel wool, chemical tray, acetone, water, packing peanuts (polymer and glucose based), goggles

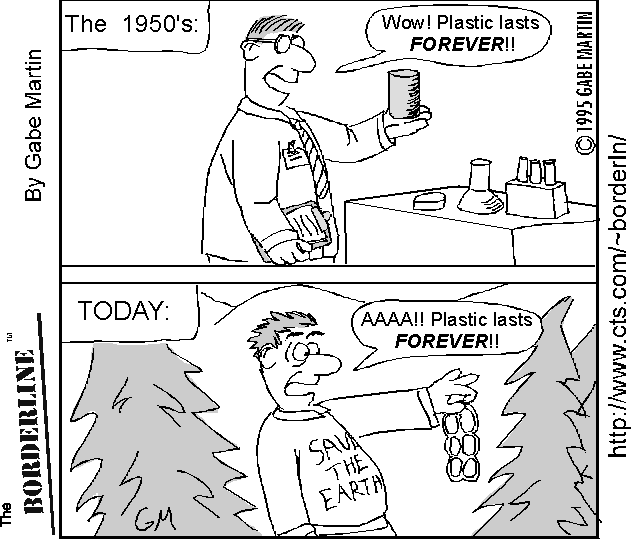
**Lesson Preparation:**

1. Bag it Discussion questions worksheet (one per student)
2. Demonstration 1: lining in aluminum cans
   1. Remove the paint from the side of an empty aluminum can using steel wool.
   2. Fill the empty can with water.
   3. Fill a 600 ml beaker with 250 ml of 1 M HCL.
   4. Place the beaker on a chemical tray.
3. Demonstration 2: degradation of packing peanuts
   1. Place two 400 ml beakers on a chemical tray.
   2. Place 200 ml water and 200 ml acetone in each beaker. Place a watch glass on the beakers.

**Time Required:** Two 50 minutes periods

**Procedure:**

**Engagement:**

* + Begin class by placing the aluminum can in the beaker of HCl. This demonstration will remain at the front of the classroom for the next day.
  + Plastics pre –assessment questions
  + Cartoon – What message is this cartoon trying to send?

**Exploration: “Where is Away?”**

1. What is plastic made from?
2. What are the beneficial properties of plastics?
3. What is the number one consumer item in the world?
4. What did Ireland and San Francisco do solve their bag problem?
5. Which is better? Paper or plastic?
6. What are some other alternatives to plastic bags?

**“Single-Use Disposable”**

1. Explain what is meant by a “single-use disposable” item.
2. Give five examples of single-use disposable items?
3. What are some alternatives to recycling plastic soda bottles as is done in Germany?
4. What is the impact of “single-use disposable” products on the US economy?
5. What is the cost of bottled water?
6. What are some things you can do at the supermarket or at school to reduce your consumption of plastic?

**Evaluating the process: “Where does recycling go?”**

1. Which plastics are recycled?
2. What decides which plastics are recycled?
3. What difference exists between recycled and down cycled?
4. What is a cradle-to-cradle design process?
5. What are the key issues of social equity that surround plastics and recycling?

**Implications for your future: North Pacific Subtropical Gyre**

1. What is the North Pacific Subtropical Gyre?
2. What is the difference between biodegradable and photodegradable?
3. Where do most plastics found in the ocean come from?
4. What happens to plastics caught in the North Pacific Subtropical Gyre?
5. How do plastics increase the bioaccumulation of toxins in marine organisms?
6. How do plastics facilitate the biomagnification of toxins in higher organisms?

**Evaluation: Questions of Health**

1. How do the US and Europe differ in their approach to new chemicals in products?
2. Why is there a growing concern over phthalates and BPA? What heath conditions and diseases are associated with each?
3. What are some common products that contain BPA?
4. In which plastics are phthalates commonly found?
5. What are some things you can do to reduce your contribution of plastic pollution?

**Day 2 demonstrations**

1. Show the students the plastic lining from the aluminum can from yesterday. Explain to them that the aluminum reacts with the metal to create aluminum chloride and hydrogen gas. They should be able to write and balance the equation for this reaction. Discuss the presence of the plastic lining. What chemicals are used in the production of this plastic lining? What are the health implications?
2. Place styrofoam packing peanuts in the beakers of water and acetone. DO the same thing for the glucose based peanuts? Why do some peanuts dissolve in the water, but not acetone? What are the properties that allow peanuts to dissolve in each solvent? What are the implications for the final breakdown of each kind of peanut?

**Homework:**

Did anything you learned in Bag it surprise you?

As you saw in Bag it, there are many ways to reduce your consumption of plastic.

* Which of these ideas would have the greatest impact on the environment?
* Which of these ways do you think will be the easiest to adopt into your lifestyle?
* Which will be the most challenging?

**Assessment:**

**Accommodations:**

Visual impairment:  Splashtop, which will allow students to display projected images onto their iPads or laptops and allow them to enlarge the images as needed.

Auditory:  classroom microphone system

**Extensions:**

**Next Generation Science Standards Grades 9-12 (Ages 14-18)**

**Students who demonstrate understanding can:**

* HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
* HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
* HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.\*
* HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.\*
* HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**References/Resources:**

Bag it discussion questions and PowerPoint

**Supplemental Lesson: Life Cycle Analysis**

**Problem Statement:** How can school lunches be modified to require less energy? This lesson introduces students to the idea of the carbon footprint: that all daily activities require energy and contribute to carbon dioxide to the atmosphere. Students will consider school lunches as one component of energy usage that they can have an impact on.

**Learning Objectives:**

Students will be able to:

* Describe the steps in a product life cycle assessment.
* Suggest ways to reduce the environmental impacts of engineered products.
* Explain how a life cycle assessment is a useful tool for engineers.
* Identify the seven main life-cycle stages of a product.

**Materials:** Laptops or iPads (one per student), PowerPoint

**Lesson Preparation:** PowerPoint, Internet access: The Story of Stuff, electronic or paper copies of Product Development and the Environment Activity – Life Cycle Assessment Worksheet, various articles on school cafeterias

**Time Required:** One 50 minutes periods

**Procedure:**

**Engagement: The Story of Stuff**

Play the introductory clip on the Story of Stuff (<http://storyofstuff.org/movies/story-of-stuff/>)

1. What is the materials economy?
2. What are some of the limitations to the materials economy?
3. Where do the materials used in products come from?
4. What percent of the materials used to make products are useful?

**Exploration: Life Cycle Analysis … What is it?**

1. Compare two products: Soda Pop and Chips

Discuss the raw materials used in the production of these products.

1. Introduce a simple product life cycle. Explain how energy and materials are both inputs and outputs at each step in the process.
2. Discuss the seven stages of a generic life cycle.

* Raw Materials extraction
* Component Transportation
* Product Manufacturing
* Product Distribution
* Consumer Purchase & retail
* Consumer User
* Disposal

1. Students should analyze one cafeteria product from breakfast or lunch using the Product Development and the Environment Activity – Life Cycle Assessment Worksheet taken from Teach Engineering (<https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_life/cub_life_lesson01_activity1.xml>)

**Evaluating the process: Life Cycle Assessment**

1. Materials: Which materials were used to make the product e.g. plastics, metals? What impact do those materials have on the environment during extraction?
2. Production: How and where was the product made? Was it made overseas? What energy was involved in its manufacture?
3. Distribution: How was the product distributed throughout its lifecycle, from sourcing through to final disposal?
4. Sales: How was it sold and marketed e.g via the internet, flyers, shops?
5. Use: How is it used? Does it need more energy/batteries throughout its use?
6. Disposal: How can it be disposed of or recycled e.g. through charity shops, landfill sites?

**Implications:**

1. How did the overall environmental impact of your product compare with another product in your class?
2. What could you change in your product to improve its impact on the environment? Describe your improvements here.
3. What would you need to do to reduce the environmental impact of your product even more?
4. Re-calculate your score if you were to use the improvements you just described. Did your score change? By how much?

**Evaluation: Reducing your Impact.**

1. Could you choose different materials, or use less of any of the materials?
2. Could you ensure the miners and farmers get a fair wage?
3. How could you reduce the energy used to transport the product?
4. How could you ensure good working conditions for factory workers?
5. How could the product be disposed of differently?

**Homework:**

1. Background information gathering.
2. Read and take notes on articles in the OutBox.
3. Make a list of your best ideas in a pros and cons table (you need at least 10 possibilities.
4. List products and possible changes that you could make to these products.
5. You are in a competition to secure your topic. You will use a decision tree to justify why you should get research topic. IT IS ABOUT SUSTAINABILTY.

**Assessment:**

Formative assessment: Worksheet completion and homework assignments.

**Accommodations:**

**Extensions:**

**Next Generation Science Standards Grades 9-12 (Ages 14-18)**

**Students who demonstrate understanding can:**

* HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
* HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
* HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.\*
* HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.\*
* HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**References/Resources:**

* Life-Cycle Thinking and Personal Carbon Footprint, Leonard Gelfand Center; Carnegee Mellon University, <http://www.cmu.edu/gelfand/k12-teachers/succeed/climate-environment-lesson-plans/lct-personal-carbon-footprint.html>
* Carbon Emissions Calculator. "Carbon Emissions Calculator." *Lehigh University*. Lehigh University. Web. 28 Jun 2013. <Carbon Emissions Calculator: <http://www.ei.lehigh.edu/learners/cc/carboncalc.html>>.
* Earth Day Network <http://www.earthday.org/footprint-calculator>
* Product Life Cycle; PBS; <http://www.pbslearningmedia.org/resource/lpsc10.sci.life.lp_product/product-life-cycle/>
* Whole Systems and Lifecycle Thinking; Autodesk: Sustainability Workshop; <http://sustainabilityworkshop.autodesk.com/products/whole-systems-and-lifecycle-thinking>
* Practical Action; [www.practicalaction.org/education/sustainable\_design\_technology](http://www.practicalaction.org/education/sustainable_design_technology)
* Hands-on Activity: Product Development and the Environment
* Teach Engineering: Product Development and the Environment; Contributed by: Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder; <https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_life/cub_life_lesson01_activity1.xml>

**Supplemental Lesson: Polymers and Plastics**

**Problem Statement:** How can school lunches be modified to require less energy? This lesson introduces students to the idea of the carbon footprint: that all daily activities require energy and contribute to carbon dioxide to the atmosphere. Students will consider school lunches as one component of energy usage that they can have an impact on.

**Learning Objectives:**

Students will be able to:

* Explain the chemistry behind plastics.
* Identify the different types of plastics.
* Compare and contrast petroleum based plastics and bioplastics.

**Materials:** Laptops or iPads (one per student), PowerPoint; 2 wooden stir sticks 2 small bags, 2 small cups (reused), 1 black marker, Graduated cylinder, PVA solution, BORAX solution, 1 tablespoon, cornstarch, 2 drops corn oil, Zip-lock plastic bag, 1 tablespoon water, Food coloring, Microwave oven

**Lesson Preparation:** PowerPoint, prepare solutions for labs

**Time Required:** Two 50 minutes periods

**Procedure:**

**Engagement:**

Students will take notes on polymers. Key terms: monomer, polymer, polymerization, natural, synthetic, petroleum, types of polymers, recycle classification of plastics, problems and concerns related to petroleum based plastics.

**Super Slime Polymer (Mrs. Tracy Trimpe; Havana Junior High School)**

Materials

2 wooden stir sticks   
2 small bags

2 small cups (reused)  
1 black marker

Graduated cylinder

PVA solution  
BORAX solution

Instructions

1. Use a clean graduated cylinder to measure out 20 ml of the PVA solution and pour into a clean plastic cup.
2. Use a clean graduated cylinder to measure out 4 ml of Borax solution and pour it into the cup. Stir with a stick.
3. Once the Super Slime is formed, remove from the cup and knead with your hands for several minutes to get it to the right slime consistency.
4. Put your Super Slime into a small plastic bag. Use a marker to label your bag of slime and place in the correct area.
5. Use a dry paper towel to wipe out your cup and clean your hands. Save the cup if you want to make another batch of slime. Do not wash your cup or hands in the sink until you have wiped off all of the slime gunk

**Evaluation: Bioplastics**

Students will take notes on bioplastics. This will include a simple discussion of how these plastics are made and how the differ from petroleum based plastics. Students should discuss the concerns and benefits of making and using petroleum based plastics. Students will create samples of a corn-based bioplastic

**Corn-based Bioplastic (ChemMatters, April 2010, page 12)**

Materials

1 tablespoon cornstarch

2 drops corn oil

Zip-lock plastic bag

1 tablespoon water

Food coloring

Microwave oven

Instructions

1. Place the cornstarch in a plastic bag.
2. Add corn oil and water.
3. Seal the bag and mix the ingredients by rubbing outside the bag with your fingers.
4. Add two drops of food coloring.
5. Seal and mix again.
6. Open the seal slightly and place the bag in the microwave.
7. Microwave on high 20-25 seconds.
8. While the plastic is still warm, shape it into a ball.
9. Is it biodegradable? Place it in water and leave for the week.

**Homework: Reflection**

1. What is a polymer?
2. What are the properties that make polymers so successful in our society?
3. Do plastics have a place in our society?
4. How should plastics be used in our society?
5. Are bioplastics better that petroleum based plastics?

**Assessment:**

Formative assessment: Observations and Reflection.

**Accommodations:**

**Extensions:**

**Next Generation Science Standards Grades 9-12 (Ages 14-18)**

**Students who demonstrate understanding can:**

* HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
* HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
* HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.\*
* HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.\*
* HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**References/Resources:**

ChemMatters, April 2010, page 12

[1] The sub-sections of the procedure section (e.g., Understand the Problem, Explore the Problem) are from the Illinois Math and Science Academy’s PBL Teaching and Learning Template, however, the descriptions were developed by WABS and do not necessarily represent the views of IMSA.