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What A Waste! A Secondary Environmental Science Unit On Waste Reduction And Management

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WHAT A WASTE!

A SECONDARY ENVIRONMENTAL SCIENCE UNIT ON WASTE REDUCTION AND MANAGEMENT

by

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Project Summary

Introduction

"There is no such thing as 'away', when we throw anything away it must go somewhere." This quote, spoken by Annie Leonard (2007) in her short film, *The Story of Stuff*, set the tone for this entire project. Wastefulness is a gigantic problem in our country and the upcoming generations have the ability to change it; but they need to know where to start. The purpose behind this capstone project is to increase engagement, passion and connection with the environment through learning about waste. Through the unit lessons and projects, the research question of: *does teaching environmental science through waste reduction and management in an urban classroom affect student engagement and connection?* is implemented and explored.

Unit Plan and Design

Within this unit of lessons students are exposed to the process of waste generation and the consequences of squandering our resources. Students gain ownership in their learning by participating in independent and collaborative projects and incorporate engineering concepts to design and implement their own waste reduction plans and track the progress of these plans over time. This project focuses on using materials that are easily sourced or readily available without major funding while staying true to the core of urban environmental education.

Urban environmental education focuses on using the surrounding environment to educate students. By bringing students out into the community and exposing them to the environmental issues and concepts that are found in a metropolitan area, real world,

applicable learning can take place. As described in my paper, this authentic learning can be achieved through the use of place-based pedagogy in which the student's immediate environment is used to spark inquiry. The curriculum presented in this project allows students to gain community exposure while using critical thinking and STEM principles to create solutions to the waste problem in our daily lives.

Timeline

The following project includes a 10 lesson unit on waste reduction and management designed for a secondary urban high school science class. These 50-150 minute lessons can be taught in as little as 3-4 weeks, but can also be stretched and adapted to cover a longer period of time. This lesson is best taught during the spring or fall when temperatures are mild and students are able to be outside for extended periods of time. This unit can be taught to a class size as small as 10 or to a larger class of 30 or more.

Setting and Participants

This project takes place in a Minnesota urban high school. The school includes 180 students mainly from the surrounding northeast metropolitan suburbs. The school make-up includes the following: 64% male students, 36% female, 64% minority students and 72% disadvantaged students with free or reduced lunch pricing. The school serves as an Alternative Learning Center that focuses on credit recovery opportunities for students who are falling behind in their studies. Many of these students performed poorly in a traditional learning establishment and thrive by working on hands-on projects and inquiry-based lessons. The participants in my class have a mix of abilities with a handful

of students with an individualized education program (IEP), multiple English Language Learners (ELL), students who have been incarcerated, as well as students without housing. Students in this school are in grades 9-12+ and are between the ages of 14 and 21. The lessons and topics included in the project will be implemented into the environmental science course that is taught to mostly 9th grade students, but may also be taken as an elective course by students in any grade.

Assessment

The culmination of this project is a student designed implementation of their learning towards a part of their lives that could use less waste. Students reflect on their day to day lives and choose an aspect that generates a surplus of waste. Each student implements this plan and tracks their data. The project concludes with the student's reflection and results. This standard-aligned project allows the student to demonstrate their learning through a service minded, exploration activity that ties in a multitude of other scientific skills such as experimental design, implementation and research. Students collect data and create a poster project describing their plan and their results. At the end of the designated time period, students share their project and findings with their classmates via a gallery walk. The instructor grades the students' work via a rubric and discuss each student's project and their journey in waste reduction to ensure the student met the standard and is proficient in their understanding. Students are also assigned multiple formative assessments throughout the unit to gather data to give the instructor an idea of each students' progress. These formative assessments include worksheets, lab reports and exit tickets.

Lesson Formatting

The lesson templates used, are adapted from Understanding By Design *(Wiggins & McTighe, 2005).* The Understanding by Design framework uses the backwards design approach when constructing learning units. In this way, the learning goal is identified first and lessons are designed to allow students to show comprehension through a multitude of avenues. Through these lessons, students are supported, encouraged and constantly challenged to extend their thinking. Student progress is continually monitored to ensure the student is on track towards reaching proficiency in the learning target and standard.

Conclusion

At the conclusion of this project, students will hold a deep understanding of how waste is generated, transported and disposed of. They will also realize that we are on the fringe of a global waste crisis. We simply cannot continue to produce waste at our current rate without significant environmental and economic harm. Armed with the knowledge and skills of waste reduction and management, students can engage in their local councils, neighborhood groups and personal homes and offices to reduce their waste footprint as well as educate others about the threat we all face. As they engage with their communities and the urban environment around them, students can encourage small changes that can add up to make a world of difference in the fight against waste management and the battle to reduce, reuse and recycle. Because, there is no such thing as “away”.

Lesson 1 - An Introduction to Waste

Time Requirement:
One 50 minute period.

Lesson Objectives:
At the conclusion of this lesson, students should be able to define waste and explain why we should be concerned with the amount of waste we currently produce as well as some of the harmful effects to our environment and health.

Student Understandings:
- Student will be able to define waste and understand that waste ends up in landfills.
- Students will be able to describe the problem with waste and why we should change our behavior.
- Students will be able to list the environmental problems caused by waste.

Essential Questions:
- What is waste?
- Where does our solid waste go once it leaves our homes/schools/work?
- How much waste do we generate as Americans, as Minnesotans?
- How many recyclables do we throw away at school?

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.

Connections to Curriculum and Real World:
At this point in time, students should have a grasp on natural systems, food webs and chains, energy flow, matter and nutrient cycles as well as a general idea of interactions in the biosphere. This unit will serve as an introduction into human interactions with the environment and our effects on natural systems.

Assessment Plan
Students will be assessed in both their reflection paragraph written at the end of the hour (bellringer) and formative assessment on their participation in the activity and discussion. A formal unit project will be given at the close of the unit to determine if the student is proficient in the standard.

Evidence of Understanding
Students will demonstrate proficiency and understanding by actively participating in the discussion and activity around waste. The student will discuss their understandings with their fellow classmates and then reflect on their own on an exit ticker or bell ringer question and answer that the teacher will collect. The responses on the exit tickets will let the teacher know if the student grasps the concept or if he/she needs to spend more time on introducing waste the next day.

Materials Needed:

- Computer with internet access
- Projector with sound
- Exit tickets
- Recyclables and non recyclables for sorting activity

Lesson Guide:

1. Introduction:
    a. Play the youtube video : The Story of Stuff
        i. T/P/S activity
            1. What did you think about the video?
            2. Where does your stuff go when you are done using it?
            3. How much do you think you throw away every year? Month? Day?
2. Activities
    a. Complete the recycling game
        i. For this activity bring in personal recyclables and non recyclables. I use (egg cartons, cream cheese containers, hairspray bottles, soap bottles, styrofoam, frozen food boxes, a used cardboard pizza box, plastic bottles, plastic bags, hard plastic containers, glass bottles, pop can, soup can, ect.) It is nice to have a mix of both recyclable and not recyclable so that students understand that not everything can be recycled depending on where you live.
        ii. Set it up. Make sure that the recyclables are clean and washed so students don't get dirty. I allow them to wear gloves if they still are uncomfortable handling the materials.
        iii. Have the class form a line on one side of the room with the materials on the other side of the room. Then have two clean bins. One labeled recycling and one labeled trash. Time students to see how fast they can correctly sort the materials into the correct bins. Once they get it correct I hand out candy.
        iv. Use the game to start a discussion about recyclables. Why can some things be recycled but not others? And why does this change from city to city. Often I bring in the flyers you get in the mail that show residents which materials they can recycle and what the have to do to recycle properly (take of caps, rinse).
3. Conclude
    a. Reflection exit ticket
        i. On a half sheet of paper, write down your own recycling process. Do you recycle? Which items do you recycle? Why do you feel like it is or isn't important to recycle?
        ii. Teacher collects the responses

Lesson 2- School Waste Audit

Lesson adapted from Generation Earth Audit (MRWMD)

Time Requirement:
One 50 minute class period

Lesson Objectives:
At the conclusion of this lesson, students will collect and analyze data regarding their school's waste.

Student Understandings:
- Student will be able to chart waste production in their school.
- Students will be able to explain which areas of their schools produce the most waste.
- Students will generate and propose ideas on how this waste can be decreased.

Essential Questions:
- How much waste does my school generate?
- What areas or rooms generate the most waste?
- How could we improve our school to reduce the amount of waste we are generating?
- How am I contributing to this waste?

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.

Connections to Curriculum and Real World:
This experiential learning connects to the concept of waste and of human impact on the environment. How are the choices we make at school regarding our trash affecting our communities? Students will be able to form connections between the waste and many environmental issues they see in their communities.

Assessment Plan
Students will be formatively assessed via the worksheets that they turn in from their waste audit. The teacher will also walk around with the different groups of students as they venture through the school to do their waste audit. Students will be formally assessed with a cumulative project at the end of the unit.

Evidence of Understanding
Student learning will be observed through watching and interacting with the students as they conduct the waste audit. Student participation and engagement can be a sign of learning occurring. Students will also turn in a worksheet that lists the waste that they found as well as a reflection piece to do a self assessment of their own learning.

Materials Needed:
- Permission slips

- Gloves (enough for each student to have 2)
- Safety goggles
- Tarps for sorting
- Worksheets

Lesson Guide:

1. Introduction
    a. On the whiteboard at the front of the class, collect student ideas on where they think they will find the most waste at school. Also have them come up with what they think the most common waste product will be when they complete the audit.
2. Activity:
    a. Collect permission slips. For students to sort trash, a parent or guardian slip must be signed. If students are over 18 they may sign themselves. Sample permission slip below.
        i. On (date)_____ our class will be conducting a waste audit on our school to study the amount of waste we produce. During the audit, your student will handle solid waste and recyclables from classrooms and the cafeteria. Students will only handle dry waste. Students will have both gloves and safety goggles and will have a staff member with them at all times. We need your permission for your child to participate in this activity. To grant your permission for your student to participate, please sign below. My student,_____ has my permission to participate in the school waste audit to be conducted at School. Guardian signature:_____ Date: _____
    b. Hand out worksheets, safety gloves and goggles. Demonstrate to students how to sort through the trash safely and effectively. Never reach your hand into a garbage can, but rather dump out the trash onto a tarp in the sorting area and gently sort the materials. This way, you will not push your hand onto anything sharp that was buried in the trash.
    c. Tally the materials you find on your worksheet.
    d. Remove any recyclables you found in the trash and recycle them.
3. Clean up: Return trash bins and clean up your area.
4. Wash hands and return goggles and gloves.
5. Answer the reflection questions on your sheet and turn in.

SCHOOL WASTE AUDIT -Learn What's In Your Trash

Date_____ School Name _____ Audited Area _____

Auditing Team (Student Name(s) _____

THE AUDIT

1. **TEAM UP- Get into your teams and determine jobs: Recorder/ Collector(s)/ Counter(s), Monitor, etc.**
2. **PREP & SAFETY- Put on gloves and review safety and general directions before beginning**
3. **COLELCT- Bring containers being audited to the auditing area** (With sorting containers/ tarp if needed, etc.)
4. **SORT, COUNT and TALLY items from the trash into either the TRASH "table" or the RECYCLABLES "table"** (If auditing more than one container note the classroom or campus location it is from.)
5. **TOTAL your counts of each item and then total the "TOTALS" column.**
6. **TAKE PICTURES IF YOU CAN.** (They're helpful for reports and Power Pt. presentations and sharing your findings.)
7. **CLEAN UP. Wash hands. Return containers and put away tools.**

AFTER THE AUDIT

1. **DISCUSS findings with group.**
2. **ANSWER questions (on other side).**
3. **REPORT, SHARE findings with students, teacher and school administrators.**
4. **DEVELOP and DECIDE on RECOMMENDATION and PLAN of ACTION!**

TRASH	ITEMS FOUND	TALLY ____	TALLY ____	TALLY ____	TOTALS
	**Plastic Food Containers** (like: cups, juice boxes & pouches)				
	Plastic Wrappers (like: chip, snack, spork wrappers)				
	Plastic Straws				
	Styrofoam				
	Food				
	Dirty Paper (Like towels & tissues, paper cups & lunch trays)				
	Other				
	TRASH TOTAL				
RECYCLABLES	**ITEMS FOUND**	**TALLY ____**	**TALLY ____**	**TALLY ____**	**TOTALS**
	**Glass Bottles/ Jars**				
	Plastic Bottles / Containers				
	Metal/Aluminum Cans				
	Cardboard				
	Paper Packaging (Like clean lunch trays)				
	Paper used on one side				
	Paper used on both sides				
	Construction Paper				
	Magazines/Books				
	Other				
	REYCLABLE TOTAL				

TOTAL TRASH ITEMS _____ + TOTAL RECYCLABLE ITEMS _____ = TOTAL _____

MORE TO DO and QUESTIONS TO ASK

1) **From the items found, what percentage can be recycled? _____**
   The Math: ({Total of RECYCLABLES} ÷ by {Total of recyclables & trash amounts} x 100 = %)?
2) **What percentage can be composted (food)? _____**
   The Math: ({Total of FOOD} } ÷ by { Total of recyclables & trash amounts} x 100 = %)?
3) **What percentage is actually "trash?" _____**
   The Math: ({Total of TRASH} } ÷ by { Total of recyclables & trash amounts} x 100 = %)?
4) **Which items were trashed the most? _____**
5) **Did you find "single use plastics" ? If so, how many items did you find? _____**
6) **Create a list of alternatives for the "highly trashed" items. _____**
   For example, cloth bags instead of plastic shopping bags, or reusable water bottle.
7) **Of the paper found in trash cans, estimate percentage used on both sides of the paper? _____**
8) **Interview students and teacher to find out if they use both sides of the paper when copying or taking notes. If not, why not? _____**
9) **Is there a recycling program on campus?_____ Is it being used? _____ If not, find out why._____**
10) **If there is a recycling program do you think that students and staff could recycle more? _____**
    What materials? _____
    How can your team encourage this? (raise awareness, awards, etc.) **_____**

MAKE RECOMMENDATIONS – HERE'S SOME IDEAS

TEN THINGS YOU CAN DO TO REDUCE WASTE IN CLASSROOM/OFFICES	
Use paper on both sides for copies and turning in assignments. Most copiers can make double sided copies	Use refillable pens and pencils. Arrange with your teachers to turn in assignments electronically.
Avoid printing extra handouts	Reuse manila envelopes and file folders
Keep a box of scratch paper to be used by others	Purchase office supplies from manufacturers that use less packaging and recycled materials.
Maximize use of overhead projectors, blackboards or dry-eraser board to minimize handouts.	Buy recycled paper products
Recycle paper and cardboard	Arrange extra credit for students who monitor trash cans.
TEN THINGS YOU CAN DO TO REDUCE WASTE at LUNCH & SNACK	
Use reusable trays, dishes, cups and utensils.	Buy supplies packaged in recyclable materials.
Use a sports bottle that can be refilled.	Buy food supplies in bulk.
Serve sandwiches in plastic wrap instead of packaged plastic containers.	Use refillable condiment bottles like ketch up and salad dressings and purchase refills in bulk quantities.
Recycle cans, plastic, bottles and paper.	Collect food waste for composting
Use utensil and napkin dispensers so students can take only what they need.	Write a letter to your District's Nutrition Services Director to share your findings and recommendations for reducing waste during lunch and snack.

Lesson 3- Tour de Trash: A Dumpy Field Trip

Time Requirement:
50 mins + travel time

Lesson Objectives:
At the conclusion of this lesson, students will be able to explain what happens to solid trash after it is taken away by the garbage truck.

Student Understandings:
- Solid waste is collected and brought to a dumping station or landfill.
- Waste is covered and treated to increase the rate of decomposition and breakdown.
- Landfills are filling up quicker than we have projected and we need waste alternatives.

Essential Questions:
- What happens to the garbage once it leaves our homes, schools and offices?
- What processes does trash undergo at the dump?
- How can our city improve it's garbage disposal practices?

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.

Connections to Curriculum and Real World:
This experiential learning connects to the concept of waste and of human impact on the environment. How are the choices we make at school regarding our trash affecting our communities? Students will be able to form connections between the waste and many environmental issues they see in their communities.

Assessment Plan
Students will be assessed in their attentiveness and participation in the tour process as well as the thoughtfulness of their worksheet answers. Students will be formally assessed at the conclusion of this unit with a unit project.

Evidence of Understanding
Student understanding will be evident by how the student participates in the tour. Are they asking questions, are they staying with the group, are they having those ah-ha moments? The teacher can also gain an idea of if the student met the objectives by going through his/her worksheet and tour notes.

Materials Needed:
- Permission slips
- A bus
- A scheduled tour with the city waste management company
- Safety materials (provided by waste company)

- Worksheets
- Clipboards
- Pencils

Lesson Guide:

1. Before leaving, show students a picture of a dumping site. Have them tell you what it is and what happens there. Ask how these places get rid of the trash. Then tell students that today they will be visiting a sanitary station. Make sure all permission slips are signed for students under 18. Ensure that all students are aware of the safety procedures at the station.
2. Board the bus, get on the vans, or walk to your destination. Make sure students have proper supervision during the movement from classroom to dump.
3. Hand out clip boards, pencils and worksheets (on the next page). Instruct students to reflect on the experience as they go and jot down their responses to the prompts.
4. Tour the facility/grounds
5. Be mindful of who is asking questions and what types of responses they are getting back. Are they engaged? Are they asking meaningful questions or silly ones?
6. Wrap up the tour, thank the company and board the bus home!
7. Reflect on the trip. What did the students learn? Did they enjoy the trip? What did they learn about the way trash is collected and processed? Were they surprised by any part of the process?

Lesson Resource:

This lesson plan worksheet is an activity from the Environmental Activities for Youth Clubs and Camps, a resource developed by the Peace Corps Office of Overseas Programming and Training (OPATS). It was contributed by Peace Corps/Armenia.

The Garbage Dump Field Trip Worksheet

Your name: Date:

1. Identify, in writing, the location of the dump and its size (e.g., hectares, acres).

2. How do the people living in the surrounding areas use this dumping area as a waste disposal site? (Included should be a list of the major kinds of waste observed here.)

3. Dumps can be classified as sanitary landfills, rubbish burning dumps, or open dumps. Into which category does this dump fit? Why?

4. Is this a legal dumping area? (Does it conform to the legal statutes governing waste disposal?)

5. Is this dump a safety hazard? Is it accessible to little kids who can hurt themselves in it?

6. Do you note burning going on? Are toxic substances, like plastic, being burned? Is the smoke blowing into areas where people are breathing it?

7. Do you see items in the dump that should have been recycled or reused? What are they?

8. Do you find organic items that should have been composted? What are they?

9. Do you see hazardous waste items, such as motor oil, batteries, and pesticide containers, that are in the dump or even being burned? What are they?

10. Is there any evidence that animals inhabit the dump? If so, what kind? Do they appear to present health and/or safety problems?

11. Briefly describe the uses of the land areas immediately next to the dump. What kind of problems does the dump present to the people living there?

12. Are there any waterways within or near the dump site? Do they receive runoff from the dump? If so, what problems might this cause for downstream communities?

13. Is the dump an eyesore? Is it located where lots of people go, or is it out of the public view? Does it make the town significantly uglier than it has to be?

14. How long can the community rely on this site? What are future plans for waste disposal in this area?

15. Do alternatives to dumping exist in the community? If so, what are they?

16. Can the community reclaim the dump? Should they? If so, how? Are there legal restrictions or regulations governing the reclamation of garbage dumps?

17. What could your group do to attempt to improve the dump situation?

Lesson 4: Intro to Plastics and its Properties

Lesson modified from ©2010 Wake County Environmental Services, Solid Waste Management Division, Raleigh, NC

Time Requirement:
50+ mins

Lesson Objectives:
At the conclusion of this lesson, students will have sorted plastics based on their properties and explored each of these properties.

Student Understandings:
- Student will be able to recognize the differences between types of plastics.
- Student will be able to identify and sort plastics by their identification number.
- Students will investigate the physical properties of plastics.

Essential Questions:
- What is plastic made of?
- How do I use plastic in my daily life?
- What are the different types of plastics?
- What do the numbers on the bottom of plastic containers mean?
- What are the physical and chemical properties of plastics?

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.

Connections to Curriculum and Real World:
People use plastic almost every day. Many use it in ways they don't even realize. People also dispose of these plastics every day. This lesson allows students to explore the world of plastic and learn how to properly sort and recycle plastic materials and why this is an important part of the recycling process.

Assessment Plan
Students will be assessed through their worksheets which will be turned in at the end of the lab. Students will also be assessed informally during the activity by the teacher as he/she walks around and asks questions/interacts with the students.

Evidence of Understanding
Students will demonstrate their understanding by their participation in the lab activity. Are they participating? Are they filling out the worksheet correctly, are they asking questions to dig deeper? The teacher can also check the lab questions and see if the student got the answers correct. If the student needs further interventions the teacher should meet with the student one on one to remedy their confusion.

Materials Needed:
- **Samples of different plastics (#1-#6)**

- **“Common plastics” information sheet**
- **Student lab worksheets and answer keys**
- **Application question sheet**
- **5 or more beakers**
- **Water**
- **Salt**
- **Corn syrup**
- **Isopropyl alcohol**
- **Vegetable oil**
- **Wood stirring sticks**

Lesson Guide:

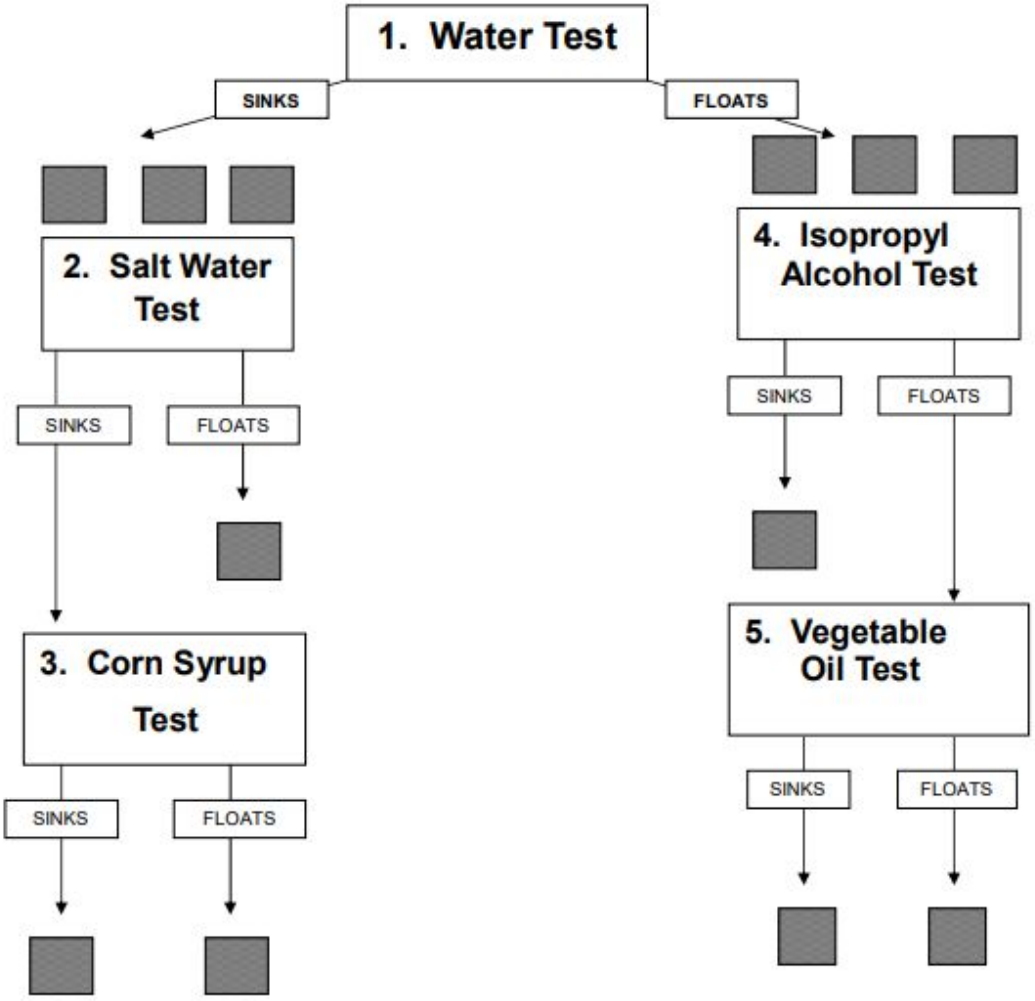
1. Introduction Activity (Part 1)
    a. Place collected plastics in a location of the classroom that is accessible by the majority of students. Students will devise a method to sort and count the plastics of each type. Students will then record and graph the results.
    b. Ask students to hypothesize why there are so many different types of plastics. Have them look at their results and identify any types of plastics that are more common than others. Ask them to provide reasons for why this might be so.
    c. Pass examples of plastics 1-6 around the room. Students will record observations on the Observations Worksheet about the physical properties of each plastic as they view them.
2. Exploration Activity (Part 1)
    a. Students work in cooperative groups of 3-4 to complete this part of the activity. Enough materials should be prepared so that each group has a complete set OR materials should be distributed and set up at 5 stations so that student groups can rotate through the stations.
        i. Instruct students that one of the easiest ways to classify plastics is by their densities. Density is the amount of mass an object or substance has divided by the volume of the object or substance. Each type of plastic has a specific density range and by observing what a plastic does when placed in various liquids (float vs. sink) density ranges can be determined for identification of plastic types. This technique is used to sort plastics during the recycling process.
        ii. Review safety procedures for working with chemicals and equipment.
        iii. Distribute materials and worksheets to students.
        iv. Students will then follow the flow chart to perform density tests on all plastic samples using the following liquid substances.
            1. Water (density = 1.0 g/mL)
            2. Salt Water -1200g salt per 1 L of water - (D=1.2 g/mL)
            3. Corn Syrup (D= 1.36 g/mL)
            4. Isopropyl Alcohol (D=.94 g/mL)
            5. Vegetable Oil (D=0.90 g/mL)

v. Students will use their observations and the density rage values given on the Characteristics of Common Plastics information sheet to identify the plastics and fill-in the shaded boxes on the flow chart worksheet with the appropriate plastics number as they complete the tests. Students will answer questions using the information they have gained during the experiment.

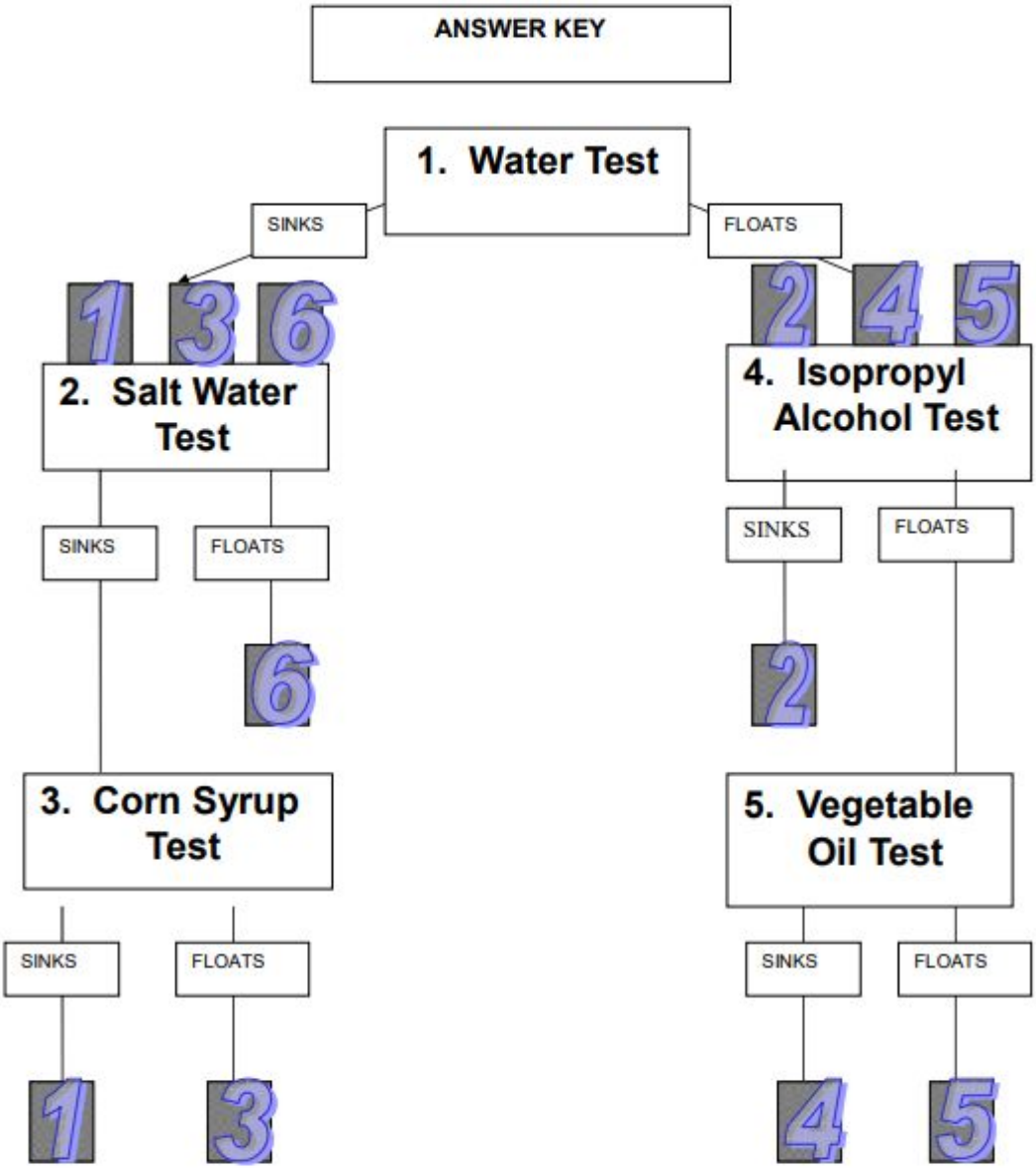
3. Extension Activities:
    a. Plastics Type #7 (Other) is used to categorize any plastic that does not fit into one of the other types. It is often a multi-layer plastic made by combining two or more of the other plastic types.
    b. Provide students with several different samples of Plastics #7.
    c. Have them try different variations of the density tests to find out if each #7 sample plastics produces the same results. For example, did each #7 sample float in water? Sink? What about in the isopropyl alcohol?
    d. Ask students to try to provide a density range value for Plastic #7.
    e. Can also make polymer slime with Borax to demonstrate the structure of the molecular bonds of polymer!

All About Plastics

Follow the flow chart, performing each test as numbered in order. Please note that you will NOT use all 6 plastic samples for each test. After completing each test, determine which plastics (of the ones used for that particular test) sink and which float. Then record the answers in the appropriate shaded boxes or continue on to the next test.



All About Plastics



All About Plastics

Name_____

Observations Worksheet

Plastics Type (#)	Observations
1 PETE	
2 HDPE	
3 PVC	
4 LDPE	
5 PP	
6 PS	

All About Plastics

Name_____

Application & Conclusion Questions

1. A lifeguard sees a young child fall into the neighborhood pool. There are 6 plastic life preservers labeled 1, 2, 3, 4, 5, and 6. If the labels identify the type of plastic each is made of, which three would be the best to grab to save the child? Why?

2. A ship carrying empty milk jugs down the Mississippi River has a spill, and the jugs go overboard. What will happen to the jugs when they hit the water?

3. What do you think would happen to the jugs when they reach the salt waters of the Gulf of Mexico? Explain your answer.

4. A local water park has a new ride called the Slime Flume. The slime used in the ride has a density of 1.15 g/mL. What type(s) of plastic would be best to use for making the floats for the ride?

Application & Conclusion Questions

ANSWER KEY

1. A lifeguard sees a young child fall into the neighborhood pool. There are 6 plastic life preservers labeled 1, 2, 3, 4, 5, and 6. If the labels identify the type of plastic each is made of, which three

The life preservers made from plastics 2, 4, and 5 would be best since they float when placed in water.

2. A ship carrying empty milk jugs down the Missis sippi River has a spill, and the jugs go overboard. What will happen to the jugs when they hit the water?

The jugs will float. Milk jugs are made from HDPE (plastic #2) which floats when placed in water.

3. What do you think would happen to the jugs when they reach the salt waters of the Gulf of Mexico? Explain your answer.

The jugs would still float. The density range of HDPE is 0.95 – 0.97g/mL. The density of salt water is 1.20 g/mL. Therefore, the HDPE is less dense and will float on the more dense salt water.

4. A local water park has a new ride called the Slime Flume. The slime used in the ride has a density of 1.15 g/mL. What type(s) of plastic would be best to use for making the floats for the ride?

Plastics 2, 4, 5, and 6 could all be used to make the floats since they all have density ranges less than the density of the slime.

All About Plastics

Characteristics of Plastics Information Sheet

Plastic Type	Name	Properties	Density	Common
	Polyethylene Terephthalate	Tough, rigid, shatter-resistant, softens if heated	1.38-1.39 g/mL	Soda, water, juice, and cooking oil bottles
	High Density Polyethylene	Semi-rigid, tough, flexible	0.95-0.97 g/mL	Milk and water jugs, bleach bottles
	Polyvinyl Chloride	Strong, semi-rigid, glossy	1.16-1.35 g/mL	Detergent bottles, shampoo bottles, shrink wrap, pipes
	Low Density Polyethylene	Flexible, not crinkly, moisture-proof	0.92-0.94g/mL	Garbage bags, sandwich bags, 6-pack rings
	Polypropylene	Non-glossy, semi-rigid	0.90-0.91 g/mL	Yogurt cups, margarine tubs, screw-on lids/caps
	Polystyrene	Often brittle, sometimes glossy, often has strong chemical reactions	1.05-1.07 g/mL	Styrofoam, egg cartons, packing pellets, take-out containers

Lesson Five: Wash up!

Time Requirement:

One - two 50 minute class periods

Lesson Objectives:

At the conclusion of this lesson students should be aware of the plastics that can be found in their body and beauty products and design an experiment to reduce the amount of plastics we put into our water systems.

Student Understandings:

- Students will be able to evaluate the environmental impacts of personal care products.
- Develop and test a model for an innovative and efficient water filtration system and recover contaminants/resources.

Essential Questions:

- Why types of plastics are found in beauty and personal care products?
- What happens to these plastics once they are washed down the drain?
- How can we prevent these small plastics from entering the water and sewage systems?

Standards addressed

MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.
MN 9.1.1.2.1 - Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world**.**

Connections to Curriculum and Real World:

Plastic pollution has been around since the plastic age began in the mid-twentieth century. Today more and more researchers are investigating the impacts of plastics on the health of humans and other species. In addition, awareness is growing about the existence of plastic “sinks” in the ocean where large amounts of buoyant, lightweight waste accumulate.

Many commercial products contain plastic microbeads. For example, they are specifically added into some facial cleansers for the advertised purpose of the “deep exfoliating” of skin. Although they are small, the plastic microbeads that are present in facial cleansers and shower gels and even toothpaste can also contribute to these plastic ocean “gyres”. We are now realizing that these and other personal care products (PCPs) are pollution! Microplastics usually slip right through our municipal water treatment plants and find their way into rivers, lakes and oceans, so environmental engineers are developing technologies to filter microbeads from water.

Microplastics are particles of various types of plastic classified by the U.S National Oceanic and Atmospheric Administration as being less than 5mm diameter. These might be broken down pieces of larger plastic items or manufactured microbeads intended to clean skin. Because they are found in various shapes and sizes, are not predictably biodegraded, and are non-magnetic, microplastics are difficult to filter out and can easily pass through wastewater treatment plants and into waterways. Microplastics are increasingly found in aquatic food webs, prompting attempts around the world to eliminate plastic microbeads from consumer products and research better ways to remove these pollutants from the environment.

Assessment Plan

Activity Embedded Assessment: As teams are working to develop successful microplastic filters, watch that students work together in groups to design, construct and use the filters, aiming for every student to have the opportunity to contribute to the design-build-test-process.
Group/Self Evaluation: Conclude the activity by having students individually provide written answers to the reflection questions on the Microplastic Masses Worksheet.

1. How did your team do?
2. Why did you take the steps you did with your team?
3. What proportion of your initial cleanser sample was extracted as beads?
4. Provide details about why your method was or was not effective.
5. What steps would you take next time to improve the method/procedure?
6. How effective were you as a productive group member?

Evidence of Understanding

Student understanding will be evident by the responses the students write on their lab worksheets. The teacher may also walk around the room and engage with the students in dialogue about the lab, thereby getting a feel for student comprehension. I brief large group discussion or exit ticket can be added to the end of the hour to wrap up and ensure the objective was met.

Materials Needed:

For the entire class:

- Tablespoons, 1 per team, for giving each team a cleanser sample for microbead extraction; same for all teams; measure empty tablespoon and provide weight to students.
- Scale to measure milligrams more precisely
- Water
- Tech to show video clip (if desired)

For each group:

- Small whiteboard with markers
- 3 coffee filters unbleached #4 or #5
- 1 funnel (4.25 inches or so)
- 1 syringe (100mL)
- 30 cm tubing; the funnel should fit inside the tube, so the .5-inch outer diameter x ⅜ inch inner diameter x 10 feet clear vinyl tubing should fit around the lip of the funnel tube

- 1 beaker with 30 ml of water;students may need all this water!
- 1 wastewater containerd, a small plastic bag or Tupperware container
- 1 tablespoon of cleanser with microplastic beans (ex. Clean & Clear Morning Burst Oil-Free Hydrating Facial Cleanser)
- Safety goggles (1 per student)
- Lab worksheet - one per student

Lesson Guide:

1. Introduction
    a. Ask students how many of them use an exfoliating cleanser at home (soap, face wash, body wash). Ask them why these products are exfoliating? How does it work? After a few ideas are generated, tell them that these products are full of small pieces of plastics.
    b. Show the three-minute video clip from 5Gyres, *Plastic Pollution in the World's Oceans from Chris Jones* at https://player.vimeo.com/video/113359330
    c. Have students brainstorm and talk in their teams to hypothesize ways to remove the microplastics in the commercial cleanser product for further observation. Suggest that students carefully observe and touch the cleanser. Direct them to write down their ideas and plans in the form of diagrams and sketches on a group whiteboard. Expect them to end up with a general agreed-upon plan/procedure/method for extracting microbeads from the cleanser.
2. Before the Activity
    a. Gather materials and make copies of the Microplastic Masses worksheet.
    b. Using the scale, measure and record the empty weight of one tablespoon. You will provide this weight to the students so that they can determine the initial mass of the samples.
    c. Prepare tablespoon samples of the commercial cleanser, one per group. Set aside.
    d. Organize the rest of the materials, one pile per group.
    e. Have the commercial cleanser product on hand for informal and general examination during team brainstorming.
3. With the Students: Designing a Filter for Microplastics
    a. Give each group 1 tablespoon of cleanser. Inform the groups that they will each receive only one tablespoon, so they need to take care to avoid spilling it or using it without planning ahead.
    b. Distribute the worksheet and tell students the empty tablespoon weight. Have students place the tablespoon with cleanser sample on the scale, and then calculate the initial mass of the sample.
    c. Direct students to collect their teams' materials and set them on their tables. Then have students talk within their groups about what they could do with the provided materials to accomplish the challenge. Encourage all group members to contribute to the discussion.

d. Then have students alter their earlier pre-activity brainstorming filter diagrams/plans to figure out how they could set up the given materials to extract the plastic beads from the cleanser sample. Make a final design plan of the worksheet in the form of a diagram or sketch with materials indicated.
e. Require each group to show its final filter diagram to the teacher before constructing it. Alert them to be prepared to answer clarifying questions to explain the filter logic. The teacher does not provide advice but just asks students to explain the reasoning behind the design with prompts such as; explain why you have set up the filter this way.
f. After approval, have teams set up their filter systems and begin extracting microbeads. Remind them of the goal; to extract as many clean beads as possible.
g. Direct the groups to set aside all their extracted beads on coffee filters to dry undisturbed. Make sure students identify the coffee filters with team/student names.
h. The following class period, after the beads and filter are completely dry, determine which group executed the most effective filtration system by weighing the dry extracted beads for each term.
i. Lead a short discussion to share, compare and evaluate results across all teams.
j. Give students time to add to their worksheets their redesign/improvement ideas in the form of notes and revisions to the original team diagram/sketch to show any changes they would make after observing other groups systems and microplastics extraction results.
k. As a post-activity assessment, have students answer the worksheet reflection questions, as described in the assessment section.

Extension Activity:

Students could then create a poster depicting their learnings about microplastics. These small posters could be placed around the hallways at school to promote awareness for other classmates.

Microplastic Masses Worksheet

Engineering Design Challenge: To work as environmental engineers to develop a method to remove as many plastic microbeads as possible from a 1 tablespoon sample of a commercial cleanser product. After extraction and drying, the beads will be weighed.

1. **Record the known masses of the tablespoon and cleanser to determine the initial cleanser mass.**

   Mass of empty tablespoon (mass provided by teacher) = _____

   Mass of tablespoon + cleanser sample = _____

   Mass of cleanser sample = _____

2. **Our team's best filtering idea/plan using the provided materials.** Make a sketch or diagram with materials indicated.

3. **Construct your filter. Extract and save micro beads to dry on filter papers labeled with team name.**

4. **After beads and filter have dried, record the mass of the collected beads.**

   Mass of extracted microplastic beads = _____

5. **Notes about possible improvement and redesign ideas.** Feel free to make notations/changes on the original design plan above.

6. **Reflection questions.** (Write answers on other side of this sheet.)
   A. How did your team do?
   B. Why did you take the steps you did with your team?
   C. What proportion of your initial cleanser sample was extracted as beads?
   D. Provide details about why your method was or was not effective.
   E. What steps would you take next time to improve the method/procedure?
   F. How effective were you as a productive group member?

Lesson 6: Recycling Plant Tour

Time Requirement:
50 mins + travel time

Lesson Objectives:
At the conclusion of this lesson, students will be able to explain the path recyclables take from when they are placed in a recycling bin, to when they are processed at a recycling plant.

Student Understandings:
- Students will be able to describe the workings of a recycling plant.
- Students will be able to explain how plastics and metals are recycled.

Essential Questions:
- What happens to the recycling once it leaves our homes, schools and offices?
- Why is important to recycle materials?
- How can our city improve it's recycling practices?

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.

Connections to Curriculum and Real World:
This experiential learning connects to the concept of waste and of human impact on the environment. How are the choices we make at school regarding our recycling affecting our communities? Students will be able to form connections between the recycling that they participate in and the many environmental issues they see in their communities.

Assessment Plan
Students will be assessed in their attentiveness and participation in the tour process as well as the thoughtfulness of their reflection answers. Students will be formally assessed at the conclusion of this unit with a unit project.

Evidence of Understanding
Student understanding will be evident by how the student participates in the tour. Are they asking questions, are they staying with the group, are they having those ah-ha moments? The teacher can also gain an idea of if the student met the objectives by going through his/her worksheet and tour notes.

Materials Needed:
- Permission slips
- A bus
- A scheduled tour with a local recycling company. These tours are often available and include an education program plus a tour of the facility. To find a plant that schedules tours near you, google Recycling Plant Tour (YOUR CITY). Twin

Cities Metro area recycling plant Eureka! Offes tours once a week.

- Safety materials (provided by recycling company)
- Half sheets of papers
- Pencils

Lesson Guide:

Before the tour:

a. Prep students by asking them about their personal recycling practices. Do they recycle at home? At school? At work? What types of things do they put in the recycling? What do they think happens to these containers once they are picked up by the recycling company?
b. Show students a brief video clip of a recycling plant so that they know what to expect when they arrive at the plant. You may use whichever clip you would prefer. I used "The Big Sort", a SciFri clip from NPR.
c. Collect permission slips (signed by parents or guardians or the 18+ student). Students who are not touring the plant will be staying back with a teacher and conducting a research paper about the recycling process.

The tour!

d. Board the bus.
e. Take the tour. Make sure all students are using the appropriate safety equipment supplied by the recycling plant.
f. Monitor students as they tour the plant. Encourage questions about what they are seeing. Check for student engagement. Are students asking questions, are they paying attention, do they seem to be understanding the process?

After the tour:

g. Ask students about their experience. What did they learn? What was surprising to them? Did they have any misconceptions that were corrected during the tour?
h. Final Reflection: Once back, have students personally and quietly reflect on their experience by filling out a half sheet of paper. Have them turn these sheets in to you as the bell rings.

Eureka Recycling Plant Tour FAQS

RECYCLING FACILITY TOURS

Get an exciting and up-close look at the inner workings of a zero waste recycling facility!

One of only a handful of non-profit recyclers in the country, Eureka Recycling's Material Recovery Facility tour program offers an insider's look at the the buzzing world of recycling. As a zero waste demonstration and lab, touring Eureka Recycling's Material Recovery Facility (or MRF for short), shows you how recyclable materials are collected, separated, and then sold -- all within the framework of a triple bottom line business and a locally-focused social enterprise model.

Join us for a tour of our MRF and learn more about how recycling impacts our community, our local economy, and the environment.

WEEKLY PUBLIC TOURS
Eureka hosts public tours every Wednesday at 9am. Tours are limited to 10 people and are free (but donations are appreciated!)Tours booked on a first-come-first-serve basis.

EUREKA'S OPEN HOUSE
June 1st 2019
Eureka Recycling is opening its doors to Minneapolis and St. Paul residents from 9 a.m. – 1 p.m. on Saturday June 1, 2019. Tours of the facility will be offered every ½ an hour throughout the day. Learn what happens to your recycling after it leaves your cart. There's no need to RSVP, but you may reserve a spot for one of the tours.

CITY OF MINNEAPOLIS
The City of Minneapolis hosts Eureka Recycling facility tours on the third Tuesday of each month. Tours begin at 11 a.m. or 3 p.m. and last approximately 90 minutes.

If you are a Minneapolis resident and interested in touring Eureka, find out more by visiting: http://www.ci.minneapolis.mn.us/solid-waste/recycling/tours

EUREKA RECYCLING TOUR GUIDELINES

PLEASE READ BEFORE BOOKING

For safety reasons, groups are limited to 10 people per tour

Children must be 12 years of age or older

Tours last approximately 90 minutes, including an in-depth Q&A

Closed-toe shoes are required!

Requires the ability to walk up and down multiple flights of stairs and catwalks

If you or your group don't meet these requirements, no worries! Scroll to the end of this page to watch The Story of a Cereal Box, a Eureka Recycling virtual tour

Lesson 7: Composting Competition

Time Requirement:
One class period set up and multiple periods to check and record measurements. Total time = 4 weeks.

Lesson Objectives:
At the end of this lesson, students should be able to describe how the process of composting biorecycles complex organic carbon matter into simpler carbon-based organic matter and nutrients.

Student Understandings:
- Student will be able to list examples of microbes that can break down organic matter
- Describe how heat is generated when microbes break down organic matter
- Understand that to speed up the composting process, air must be included
- Explain when and how composting happens in nature
- Composting can be done in urban and home environments

Essential Questions:
- What components are needed to create a successful compost?
- What microbes are needed to break down organic materials?
- What are the optimal conditions for composting?
- Why is composting an important process in regards to reducing our disposable waste?

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.
MN 9.1.1.2.1 - Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world**.**
MN 9.4.2.2.2 - Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.

Connections to Curriculum and Real World:
Each day, we produce pounds and pounds of leftover food. What could we do rather than throw it in the trash? It could be composted! This lesson introduces the topics of microbes, nutrient cycling, decomposition, and heat production.

Assessment Plan

Activity Embedded Assessment

Questions: Throughout the course of this activity, as students take measurements and record temperature readings on their Composting Data Sheets, ask students the following questions:

- Why are we aerating one pile? (Answer: We are trying to ensure that the microbes get enough oxygen so they can do their work.)
- Where is the heat coming from? (Answer: Organic materials have lots of energy in them. If you don't believe it, try burning a log! As microbes break apart these organic materials, energy is released in the form of heat.)
- Why is important to bio recycle carbon in organic waste? (Answer: It makes simple carbon available for other organisms as food. It releases carbon dioxide that can be used in photosynthesis (or used to grow biofuels!) It also releases nutrients that can be used to fertilize other plants.

Post Activity Assessment

Worksheet: Have students fill out the Composting:Putting Microbes to Work (Again!) Worksheet. Review the answers as a class to make sure students understand the concepts.

Data Graphing: Have students plot their many weeks worth of collected temperature data and analyze what it means. Direct students to each create one graph with time on the x-axis and temperature on the y-axis. Plot the data from the two piles on the same graph using different colored pencils/markers for each data set, so as to compare the behavior of the two piles (control vs treated). As a class, guide students to interpret their data. Ask them:

- Does the data support the hypothesis (that the aerated pile becomes hotter)?(Listen to student answers and expect the data to support the hypothesis.)
- Which compost pile heated up more? (Answer Expect the data and graphs to show that the treated pile heated up more.)
- Why did it get hotter? (Answer: Microbes breaking down organic materials release heat; more microbes working results in more heat released.)
- How does composting fit into the carbon cycle? (Answer: Composting biorecyclings complex organic carbon matter into simpler carbon-based organic matter and nutrients.)
- What are the advantages and disadvantages of "treating" a compost pile? (Example answers: Advantages include faster waste degradation, more fertilizer and nutrients produced, smaller footprint, heat produced byproduct available for some purpose. Disadvantages include cost of aeration tools, time spent to routinely aeirate.)

Evidence of Understanding

Student understanding will be evident by interacting with students as they build and tend to the compost pile. Students will also be plotting and analyzing their data. The teacher can review this data as well as their reflections to ensure that the student met the standard

and is proficient in their comprehension.

Materials Needed:

- Each Student Needs
    - Composting Data Sheet
    - Composting: Putting Microbes to Work (Again!) Worksheet
- To share with the entire class
    - Outside location to place two compost piles for a month or more, a minimum or $1m^2$ ($10.76\ ft^2$)
    - 1 truckload ($1.14\ m^3$ or 40.5 cubic feed) of yard trimmings/chipped branches and trees that are not completely degraded; tree trimming and landscaping companies often provide this service for free; alternative; search the neighborhood for bags of lawn clippings
    - Hand air mattress inflator pumping; costs $11 for a used one
    - PVC pipe, .5 meter-long segment of 1.27 (half-inch) diameter
    - New pump action sprayer; for student safety it is important that the sprayer has not previously contained pesticides; costs $20
    - 2 landscaping flags, or other way to mark the centers of the piles for daily temperature readings
    - Compost pile thermometer, available at hardware stores and gardening centers, costs $12+
    - Hacksaw
    - Lighter or hair dryer for heating PVC pipe
    - Electrical tape
    - Graph paper, colored pencils/markers, for plotting graphs
    - Worksheets

Lesson Guide:

1. Introduction
    a. Background: This activity is designed to help students understand how organic materials, such as leaves, food waste and bark, can be broken down and returned to the carbon cycle. Although composting can be a slow process, it can be accelerated by providing the microbes with what they need to thrive. For example, microbes, require oxygen and water (like us!) to break down organic materials. As microbes break things down, they release energy in the form of heat. One way to gauge how "happy" microbes are is to check the compost pile temperature. The temperature of a healthy compost pile is between 48.8 degrees C (120 degrees F) to 65.40 degrees C (150 degrees F).
2. Preparation
    a. Location prep
        i. Gather materials and make copies of the composting data sheet and the composting;putting microbes to work (again!) worksheet, one per student.

ii. Find a suitable location outside to set up and conduct the activity for four to six weeks.
iii. Decide whether or not to include students in the preparation of the aeration and water pumps, and compost piles, depending on their ages and abilities.

b. Prepare the Aeration and Water Pumps
i. To create an aeration pump, start by using a hacksaw to cut one end of the half-inch PVC pipe at a 45 degree angle.
ii. While outdoors, gently heat the other end of the PVC pipe with a lighter or hairdryer, being careful not to burn the plastic.

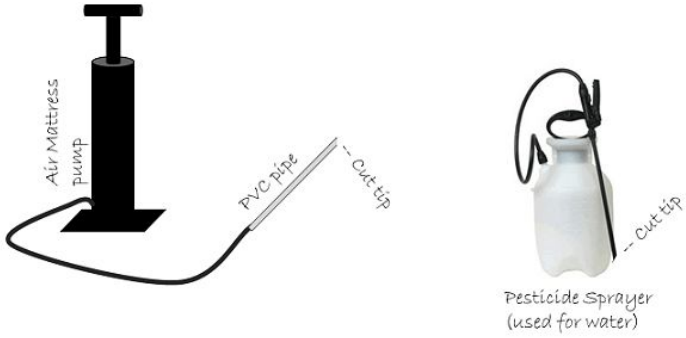


Figure 1. Modify the tools for the composting experiment.

iii. While still hot, force the heated end of the pipe onto the end of the air mattress pump hose (see Figure 1 ***© 2013 Robert Bair, Univ of S. Florida***). When cooled, the pipe should form a tight fit around the pump hose. To finalize the seal, wrap the connection between the PVC pipe and pump hose with electrical tape.
iv. To prepare the water pump, use the hacksaw to cut the tip of the pesticide sprayer at a 45 degree angle.

c. Prepare the Compost Piles
i. Evenly divide the truckload of compost into two piles and place them directly on the soil outside, in a minimum footprint of 1 m^2. One pile will be left alone as a control and the other will be watered and aerated as the "treated" pile.
ii. Visually estimate the center of the piles and mark them with landscaping flags to indicate where to take the temperature readings.
iii. With some kind of weatherproof signs, identify one pile as the control pile and the other as the aerated and watered - "treated"= pile.

3. With the students:
a. Begin by introducing the composting activity and asking students to hypothesize about what they expect to happen, as described in the assessment section.
b. On the first day, measure the temperature of both piles by placing the thermometer vertically in the center of the pile. Have students record these initial values on their data sheets.

c. Daily aeration: Every day, have students visit the treated pile and stab it with the pvc pipe, going in as far as possible. While the pipe is in, pump the inflator five times. Repeat these steps at different locations throughout the pile at least 8 times daily. Set up a schedule to share the responsibility for this chore.
d. Daily wetting: Then stab the pesticide sprayer pump into the treated pile 8 times while injecting water into the pile the entire time. Set up a schedule to share the responsibility for this chore.
e. Once the aeration and wetting process is complete, have students take temperature readings at the flag locations for both the treated and control pile, recording the measured temperatures on their data sheets. Expect the temp of the well tended pile to increase more than the control pile.
f. After 4-5 weeks, expect the aerated pile to begin to cool because the composting process has come to an end. Once this happens, the pile is ready to be added to garden soil.
g. Assign students to individually complete the worksheet. Review the answers in class.
h. Once the experiment is concluded, have students plot and analyze their data to compare the behavior of the two piles, as described in the assessment section.
i. Lead a discussion to share results and guide students in the interpretation of their data, including the pros/cons of assisting in the composting process. See the assessment section for suggested questions.

Name: _____ Date: _____ Class: _____

Composting Data Sheet

Temperature Measurements

	Day #	Control Pile Temp	Aerated Pile Temp
Start Date ➔ __/__/____	1		
	2		
	3		
	4		
	5		
	6		
	7		
Week 2 ➔	8		
	9		
	10		
	11		
	12		
	13		
	14		

Name: _____ Date: _____ Class: _____

Composting: Putting Microbes to Work (Again!) ☺ Worksheet

- **Nature's process of recycling organic materials into a rich soil is known as _____.**
- **You can turn waste materials like _____ into soil by _____!**

Title each column to describe what is similar among these two types of materials:

coffee grounds and filters cotton rags egg shells fruits and vegetables grass clippings hay and straw houseplants leaves sawdust and wood chips tea bags wool rags yard trimmings	dairy products butter milk sour cream yogurt eggs diseased or insect-ridden plants fats, grease, lard and oils meat and fish bones and scraps pet wastes (such as dog or cat feces, soiled cat litter) yard trimmings treated with chemical pesticides

The composting process requires four things:

1. _____
2. _____
3. _____
4. _____

Name: Answer Key Date: _____ Class: _____

Composting: Putting Microbes to Work (Again!) ☺ Worksheet

- **Nature's process of recycling organic materials into a rich soil is known as composting.**
- **You can turn waste materials like food waste into soil by composting!**

Title each column to describe what is similar among these two types of materials:

Compostable Materials	Non-Compostable Materials
coffee grounds and filters cotton rags egg shells fruits and vegetables grass clippings hay and straw houseplants leaves sawdust and wood chips tea bags wool rags yard trimmings	dairy products butter milk sour cream yogurt eggs diseased or insect-ridden plants fats, grease, lard and oils meat and fish bones and scraps pet wastes (such as dog or cat feces, soiled cat litter) yard trimmings treated with chemical pesticides

The composting process requires four things:

1. organic materials
2. water
3. oxygen
4. microbes

Lesson 8: Perfecting the Package

Lesson obtained and modified from Teach Engineering STEM K-12 "Making Decisions: Packaging and the Environment". Lesson contributors: Martha Cyr & K.M. Samuelson. © 2013 by the Regents of the University of Colorado; original © 2001 WEPAN/ Worcester Polytechnic Institute

Time Requirement:

One - two 50 minute class periods

Lesson Objectives:

At the conclusion of this lesson students will be able to describe why our current packaging of consumer projects is not sustainable. Students will then redesign and justify the packaging used in consumer products and design criteria that include reducing the amount of packaging material by 25%.

Student Understandings:

- Students will be able to describe some decisions related to advantages and disadvantages of the packaging process.
- Students will be able to use resources (people, references, internet) to gain knowledge.
- Students will be able to explain the impact of redesigning products and packaging materials.

Essential Questions:

- What are the other advantages of lighter packages?
- What are the recycling rates for commonly used materials?
- Are there any advantages to packaging food?

Standards addressed

MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.
MN 9.1.1.2.1 - Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world**.**

Connections to Curriculum and Real World:

Students interact with food and consumer packaging every day. They also dispose of these items every day without considering what happens to the packaging. This lesson allows students to be conscious of food and other goods packaging and explore alternative materials that could be used in place of traditional boxes and bags. This lesson relates to the curriculum unit of study in that it studies waste and how we can work to reduce or eliminate sources of waste in our country.

Assessment Plan

The assessment for this lesson will be the worksheets submitted by the students at the conclusion of the activity. Students will also be summatively assessed at the conclusion of this unit where they will create a large project that incorporates what they have learned throughout the unit.

Evidence of Understanding

Student understanding will be evident by how the student engages in the research and presentation of their project. The clarity and accuracy of their statements will let the teacher know if the student grasped the idea of packaging waste reduction or not. Students who are engaged and understanding the material will often ask multiple questions and remain on task with their research.

Materials Needed:

Each group needs a bag containing 3 packaged products from the areas of food, health or beauty aids, and some other product. Examples: boxed cookies, frozen pizza, deodorant, allergy medication, shoes, shampoo, detergent, CDs.

For the entire class to share: a few large examples of packaging, such as the boxes (and protective inside packaging, plastic bags, twist ties, instructions, etc.) that come with a new computer, TV or furniture.

Lesson Guide:

Introduction/Motivation

A new president has been elected on a platform stressing environmental awareness. The new president proposes that in addition to increasing our target goals for recycling and reusing materials, the U.S. will reduce the amount of packaging it uses by 25% within four years.

The Committee for the Protection of the Environment is designing alternative packaging that meets these new guidelines to ensure that the 25% reduction target is met. As an engineer and a member of this committee, your design challenge is to aid in the packaging reduction.

Procedure

Background

The goal is for students to understand the basics of engineering associated with packaging products and the potential impact on the environment. Packaging around consumer products serves many purposes. By holding pre-measured quantities of products, packaging makes items easier to store, ship, stack and price. Packaging offers protection from damage or breakage, as well as preservation so that food spoilage is minimized. Packages also provide information about contents and help to market products.

One strategy that helps to minimize the waste from packaging is source reduction. In contrast to reusing and recycling, this strategy is employed before items are packaged. In effect, source reduction means not using packaging that is not needed and using less of

what is necessary. Reducing packaging in this manner has the greatest potential to save resources and slow landfill depletion rates.

Four types of source reduction are lighter packaging, larger-sized packaging, flexible vs. rigid packaging, and eliminating or reducing water.

Lighter Packaging: Surprisingly, this is more important than using recyclable packaging. Since recycling levels are so low, we can usually create less packaging by choosing lighter-weight materials. (For an example, see Worksheet A: Mathematics of Packaging.) When it comes to weight, paperboard, plastic and aluminum are all efficient packaging sources.

Larger-Sized Packaging: In addition to providing cost savings, buying products in bulk results in packaging savings. (See example in Worksheet A: Mathematics of Packaging.) Note: This assumes that people only buy quantities that will be used up, otherwise spoilage loss may offset the packaging reduction benefits.

Flexible vs. Rigid Packaging: Flexible pouches can weigh up to 75 to 90% less than the rigid containers that they replace. They are also easier to compact so they take up less landfill space. A dramatic example to illustrate this is juice boxes, which are 90% lighter and take up 70% less volume than the glass bottles they replace.

Eliminating or Reducing Water: Shipping and selling products in concentrated, powdered or dried forms results in more efficient packaging. For example, concentrated powdered detergents and drink powders require the users to add water and thus enable more washes/drinks per package than if more water was included.

Before the Activity

- Gather a variety of packaged products to show as examples. Organize bags of examples for each group.
- Make copies of Worksheets A and B.

With the Students

Part 1: Redesigning Packaging

1. Spend a few minutes guiding students to share their observations about the purposes of packaging. Also discuss the differences between source reduction, recycling and reusing products. Make sure students understand that this activity is about source reduction and not the latter two strategies. Review the four types of source reduction. Hand out Worksheet A: Mathematics of Packaging and have students work through the problems. This exercise highlights the importance of source reduction in light of the low recycling rates in the U.S.
2. Divide the class into groups of 3 to 4 students. Give each group a bag containing packaging from three products. Have students think about the reasons why each kind of packaging is used. With those as a starting point, think about ways that the packaging could be reduced without compromising the product in any way. It

may be necessary to alter the product slightly such as eliminating water to reduce bulk.

3. Have students use the table on Worksheet B: Packaging to help them determine the purpose of each piece of packaging material. Have students think about whether the packaging is necessary and if so, how it might be reduced.
4. Have students draw the new packaging and discuss the ways that they changed it and why.

Part 2: Sharing Solutions

1. Have each group decide which of their packaging solutions they are most proud of. Ask for a group volunteer to show the design and explain its merits.
2. After the group has explained the design, highlight which of the four methods of source reduction they utilized. Ask another group, who used a similar strategy to explain what they did. This shows how the same strategy may be suitable for many different products. If no groups used the same strategy, then ask a group that utilized a different strategy to share their designs with the class.
3. Have each group discuss a packaging solution. If all four methods of source reduction have not been discussed, use examples to try to get students to discuss all four methods.
4. Lead a class discussion about how students approached the problem like engineers. Also discuss what types of jobs are involved in packaging.

WORKSHEET A: MATHEMATICS OF PACKAGING

A. Materials and Impact on Landfills

Facts:

- Coffee is kept freshest if packed either in steel cans or in vacuum brick packs.
- Steel is 45% recyclable (meaning 55% of it winds up in landfills and 45% can be re-used for other products.)
- Vacuum brick packs can not be recycled.

Options:

Packaging 65 pounds of coffee requires either 20 pounds of steel, or 3 pounds of vacuum brick pack material.

Problems:

1) What is the amount (weight) of material that will wind up in the landfill for each packaging choice.

2) What does the % recyclability of the steel need to be to produce the same amount of waste as the vacuum brick packs?

B. Buying in Bulk

Facts:

- A 33-ounce box measures 6 inches high by 6.5 inches wide by 3 inches deep.
- A 132-ounce box measures 9 inches high by 9 inches wide by 5 inches deep.

Problems:

1) How many square inches of material is required if you purchase 264 ounces of detergent in the small, easy to manage 33 ounce packages?

2) How many square inches of material is required if you purchase 264 ounces of detergent in the large, bulk size 132-ounce packages?

Worksheet A: Answer Guide

A. Materials and Impact on Landfill

Question 1:

55% of the steel will end up going to the landfill. This means that 11 pounds of steel will end up in the landfill.

[20 pounds x 0.55 = 11 pounds]

3 pounds of vacuum pack material will end up in the landfill.

Question 2:

85% recycle rate. At this rate, the steel produces 3 pounds of excess material that will end up in the landfill.

[1 - (3 pounds)/(20 pounds) = .85]

B. Buying in Bulk

Question 1:

Each small box has a surface area of 153 square inches. The 8 boxes have a total of 1224 square inches.

Question 2:

Each large box has a surface area of 342 square inches. The 2 boxes have a total of 684 square inches.

WORKSHEET B: PACKAGING

	1	2	3
What is the product?			
First packaging material used?			
Purpose(s) of that packaging material?			
Second packaging material used?			
Purpose(s) of that packaging material?			
Third packaging material used?			
Purpose(s) of that packaging material?			

Look at the packaging that you have listed in the table above. Circle the packaging that you think is necessary. Cross out the packaging that you think you can do away with. Then use this information to help you decide on your final redesigns for the product packaging.

Lesson 9: Get the Word Out!

Lesson obtained and modified from Teach Engineering STEM K-12 "Plastic in the Ocean:Get the Word Out at McDonalds!". Lesson contributors: Nathan Howell & Andrey Koptelov. © 2013 by the Regents of the University of Colorado; original © 2010 University of Houston

Time Requirement:
Two 50 minute class periods

Lesson Objectives:
During this lesson, students will use the internet to conduct research about the Great Pacific garbage patch and the issue of disposable plastics. Students will then create a presentation geared towards local businesses to encourage them to reduce their use of disposables in their stores.

Student Understandings:
- Students will be able to articulate in verbal and in written form some basic information about the Great Pacific garbage patch (GPGP).
- Students will be able to express and support an opinion about the conditions, causes or solutions for the GPGP.
- Students will be able to demonstrate the skill of gathering online sources of information of the GPGP without plagiarizing either in form of 1) directly copying text from articles (that is, improper paraphrasing) or 2) providing incorrect or absent citations.
- Students will be able to mix pictures and explanatory text into a short simple format that is both eye catching and informative while explaining the GPGP environmental impacts and posing environmental engineering solutions to the problem.

Essential Questions:
- **What is the great pacific garbage patch?**
- **How do restaurant materials contribute to this patch of waste?**
- **What could restaurants and other industries do to reduce their amount of waste?**
- **How would reduced waste in restaurants help recover the GPGP?**

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.
MN 9.1.1.2.1 - Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world**.**

Connections to Curriculum and Real World:
Students take part in a hypothetical scenario that challenges them to inform customers at a local restaurant of how their use and disposal of plastics relates/contributes to the Great Pacific garbage patch (GPGP). What students ultimately do is research information on the plastics pollution in the oceans and present that information as a short, eye-catching

newsletter suitable to hand out to restaurant customers. This activity focuses on teaching students to conduct their own research on a science-technology related topic and present it in a compelling manner that includes citing source information without plagiarism. By doing this, students gain experience and skills with general online searching as well as word processing and written and visual communication.

Assessment Plan

Activity Embedded Assessment

Newsletter Preparation: Use the newsletter assignment, either as a large project or as a series of mini-assignments, to assess how well students are learning GPGP-related concepts. Frequently question students on what they are writing, which helps them grasp more of what they are reading (expressing what they are learning in their own words) and how they can use it more effectively in the newsletter.

Post-Activity Assessment

Newsletter Critiques: Read and mark up newsletters. Focus most on judging the accuracy and informative nature of the text as well as correct source citations. If time permits, brief consulting time with individual students helps the assessment of student understanding and gives students helpful feedback.

Evidence of Understanding

Student understanding will be evident by the level of student engagement throughout the duration of the project. Student progress will be monitored by their contributions to in-class discussions, their focus on their newsletter preparation and their willingness to edit and improve upon their newsletter to make it accurate and in line with the parameters of the assignment.

Materials Needed:

- Computers with internet access and word processing software
- Paper or note cards to organize their thoughts and ideas

Lesson Guide:

Before the Activity

- Make certain that the word processing software and internet access are available and working on all student computers.
- Create a short handout that gives a rubric of what is required for the students or write it on the board so that students can refer to it often.
- (optional) To help in the plagiarism explanation, prepare some common examples of plagiarism from websites.
- (optional) Bring in books or printouts of other information that students could use so that they do not have to rely solely on Internet lookup information.

- (optional) As an example. write your own small newsletter in the format that you would prefer students to use. Or show students the Example GPGP Newsletter.

With the Students

1. Provide a brief oral review of the GPGP via powerpoint form. As an alternative, show a short video clip of something about the GPGP to get students' minds once again on the topic.
2. Explain the reasoning, hypothetical situation and elements of the newsletter to the class. Solicit examples from the students about topics they might want in a newsletter. To draw them in from the hypothetical, it may be helpful to bring in some plastic products from stores that you know that students often go to, or even from their own cafeteria.
3. Have students begin independent work on the newsletters. Be available for questions and walk among the computers to offer comments and suggestions.

****Here are the specific requirements of your newsletter for you to think about as you plan and write. It needs to have the following important elements.

Newsletter Title

- Something that will catch the attention of a person you hand it to outside of McDonald's. A good example might be something like, "How did plastic burger boxes end up in the middle of the Pacific Ocean?" Something more generic like "Plastic Garbage" may not be as effective but is still okay.

Name and Date

- You want people to know that you did the scientific and information research, especially so that you get credit for your original work.

Three Articles

- These articles do not and should not be too long. Three to 12 sentences is probably enough. Make sure that each article has its own separate title apart from the main newsletter title, and make sure each covers a separate Garbage Patch related topic. Here are some examples. As you read these examples, remember that you do not already have to be an expert on these topics. It is better if you are not because you will find information to teach you about them.
    - What is the Great Pacific garbage patch?
    - How was the GPGP discovered?
    - How does plastic from (insert US state) get to the middle of the Pacific Ocean?
    - Why would fish confuse plastics for food?
    - Why is the GPGP mostly plastic?
    - How does rain move plastics to the ocean?
    - How long does it take plastics in the ocean to degrade?
    - What kind of photodegradation can occur in plastics?

- Why are there ocean gyres?
- Why don't plastics just sink out there?
- What kinds of chemicals attach to plastics in the GPGP?
- How do plastics move up the food chain?
- Can plastics in fish hurt people?
- Can plastics in the GPGP be recycled?
- How would you clean up the GPGP? (This is the environmental engineering connection!)
- How fast is the GPGP growing?
- What are bioplastics and how would they help the GPGP?

Pictures

- Include no more than two pictures in the newsletter. Where possible, include a small caption below the image explaining what it is and why it is relevant to the GPGP. Be sure to note the source of your image so that it can be included in the citation section.

Sources and Citations

- At least four distinct citations are needed for the newsletter. It is best to put markings/source notes in the text to match information with source, but it is not required. Each citation needs to have these main elements organized in a consistent fashion: author, dates (of the source [if available] and the date of your access of the source), title (of web page or article) and URL.

Format

- One way to present the newsletter content is in two or three columns on a single page, but it does not have to be this way.

Lesson 10: My Waste Reduction Plan

Time Requirement:
Four 50 minute class periods (plus more time as needed)

Lesson Objectives:
This lesson allows students to take all that they have learned about waste production, reduction and management and design their own waste reduction plan. Students will then implement their personal plans, track their progress and reflect on what they have learned.

Student Understandings:
- Students will be able to describe the current waste crisis in America.
- Students will be able to create a personal waste reduction plan that will impact how much waste the individual student generates daily.

Essential Questions:
- **Where do I generate the most personal waste?**
- **What can I do/change to reduce the amount of personal waste I produce?**
- **How can I make a change that I can stick to, that fits into my routine and life, to ultimately make a difference?**

Standards addressed
MN 9.4.4.1.2 - Human activity has consequences on living organisms and ecosystems.
MN 9.1.1.2.1 - Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world**.**

Connections to Curriculum and Real World:
As humans in a first world setting, we generate an excessive amount of waste daily. With this cumulative unit project, students will be asked to think about how they generate waste and be tasked with engineering a method to reduce this waste. This lesson project sums up the preceding unit on waste reduction and management, while allowing the student to make an impactful change in their lives.

Assessment Plan
The attached rubric will be used to score this project out of 100 points. Students will be required to turn in their plans, their tracking data, their reflection and self grading sheet, on time, in order to ensure the teacher can determine if the student has reached proficiency in the standard.

Evidence of Understanding
Student understanding will be evident by the level of student engagement throughout the duration of the project. Students who are demonstrating what they learned by creating thoughtful, data driven projects that are realistic, viable, and waste focused will pass the assessment and reach proficiency.

Materials Needed:

- Computers
- Internet access
- Poster paper
- Markers
- Access to a printer

Lesson Guide:

1. Student Choice
    a. Students each choose a project topic that is personal to them and to their lives.
    b. Students design a 1-2 week plan to reduce their personal waste. The goal is to significantly change their waste output so they should think about where they generate the MOST waste.
        i. Examples:
            1. Instead of using a take-away cup from Starbucks twice a week I am going to bring my reusable coffee mug for them to fill.
            2. Instead of bringing my lunch in a plastic bag to school everyday I am going to use a reusable tupperware instead.
            3. I am only going to produce a mason jar sized amount of trash this week (all of my non recyclables/compostables will fit inside one mason jar).
            4. I am going to challenge my family to be able to change our garbage pick up from once a week to once every other week.
            5. I am going to start a compost pile at home.
            6. I am not going to purchase any new clothes or items brand new. Anything non food related will be purchased at a second hand store or from a friend.
            7. I am going to bring reusable bags to the store and not use any paper or plastic bags.
            8. I am going to change all of my personal hygiene materials to ones that don't have plastic microbeads.
            9. I am going to volunteer to clean up the local park/beach once a month to prevent trash from ending up in our waterways.
    c. Students implement their plans and track their changes. If possible, students will track their waste reduction (went to starbucks 6 times in 2 weeks so I reduced my personal waste by 6 take-away cups). Worksheet below.
    d. Students will then create a poster that explains their personal project, why they chose it, how they implemented it, what they changed, how difficult it was to make this change, how they influenced the people around them to change, and how this small change affected the amount of world waste.

e. Students will also write a personal 2 page reflection on their learning of this unit and how they plan to combat the waste problem in their lifetimes.
f. The project will be on display in the classroom for their peers to view and critique. Teachers can lead a "gallery walk" where the entire class walks around and views the posters. Teachers could use a simple worksheet to supplement the gallery walk. The personal reflections will be turned in to the teacher for grading.
g. Rubric used for grading/assessing. (Rubric below).

My Waste Reduction Plan

Introduction: Think of your daily life. Now think of waste. Where in your life do you produce the most waste? Do you stop by McDonalds on your way home everyday? Snag a disposable coffee in a Starbucks drive-thru? Buy all of your clothes new and wear them maybe once? Not recycle? Then this is the project for you! The past few weeks we have studied waste production and management. We learned what waste is, where it goes and how we can reduce the amount of waste we produce. For your final project, I want you to create your own, personal waste reduction plan. You will then carry out this plan for 2 weeks and track your progress. At the end of the two weeks you will create a poster that will be displayed to your classmates as well as write a 2 page reflection paper. The paper and poster will serve as your final assessment for this unit.

Objectives:

- Create a personal waste reduction plan
- Demonstrate how you will reduce your waste output
- Create a poster with your results
- Write a 2 page reflection paper
- Change the world!

Directions:

1. Think about your life and where you generate the most waste. Choose an area that you want to improve on. This could be recycling more, buying less things in plastic, challenging your family to waste less, making a compost pile, shopping at farmers markets with reusable bags, etc. See your teacher for more ideas if needed.
2. Create a data sheet where you can write down every time you do something to reduce your waste. It can be online or on your phone or a paper copy.
3. Track your progress for 2 WEEKS.
4. After the two weeks, take your data and start to create your poster. Your poster will include your plan, what you did to change your behavior, how much waste you saved, and how this changed your perceptions/life. We will have class time to work on this.
    a. Make sure you include a data table, your printed data sheet, or a description of your data.
    b. Make sure your poster is clear and concise, fun and informative.
5. Write your reflection paper.
    a. This will be a 2 page, double spaced paper that describes what you learned this unit. What did you think about waste before, where were you most wasteful, what do you know now, how will you continue to change?
6. Turn in both the project and paper to receive your final grade. This will be a 100 point project.

Rubric: *WASTE REDUCTION PLAN* - Total _____/100

Criteria	**Absent/beginning (0-6 points)**	**Developing(7-13)**	**Adequate(14-19)**	**Exemplary/Advanced (20-25 points)**
Waste reduction plan	Student has barely developed or not developed waste reduction plan. The plan does not contain action steps, is not feasible or does not exist.	Student has somewhat developed a plan that may be lacking adequate detail and thought. The waste reduction plan, will not significantly reduce waste..	Student has developed a realistic, attainable plan that will impact the amount of waste they produce. This plan is described, thought out and somewhat easy to follow.	Student has developed a realistic, attainable plan that will greatly impact the amount of waste they produce. This plan is well described, with plenty of detail, and well thought out and very easy to follow.
Data	The student tracked little to none of their data. Graphs and charts are missing or partially completed. Data is hard to understand or view.	The student tracked some of their data but is not presenting all of their findings on their poster. Graphs and charts are messy and mislabeled.	The student tracked their data/outcome and presented their findings. Data may be hard to interpret or missing labels.	The student tracked their data/outcome and presented their findings clearly and concisely. All data is labeled and charted correctly. Pleasing to the eye and aligned with their project.
Reflection Paper	Paper not turned in at all or on time. Draft version, many errors, not completed. Did not meet 2 page requirement.	One or more required elements missing. Revision needed. Multiple spelling and grammar errors, but turned in on time. Did not meet 2 page requirement	Some required elements may be missing such as the reflection/learnings/implementation process. The paper could use some revision, had some grammar and spelling errors, but was turned in on time. 2 pages.	All required elements included such as reflection/learnings/implementation. The paper was well crafted, had minimal grammar and spelling errors, was turned in on time. 2+ pages.
Poster project	The poster was not completed on time, is not legible, includes multiple mistakes and is missing required information. Does not include graphics.	The poster was completed on time, but is not completely finished. Multiple grammar and spelling errors, hard to read and missing some required information. May not include multiple graphics.	The poster was completed on time, mostly clean and well laid out. Most wording was legible and most required information was present. The graph did not include multiple graphics.	The poster was completed on time, was clean and well laid- out. The wording was legible & all required information was present. The poster included multiple graphics.

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