Research Experiences for Teachers (RET) – 2015
LESSON PLAN TEMPLATE - Marie Aloia

MODULE TOPIC: Polymers for Packaging - Lesson 1 - Rethink the Plastic Bag

STANDARD(S) & INDICATOR(S):
HS-ETS-1 - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

OBJECTIVE(S): Students will be able to:
"Rethink" the use of plastic bags, and design a "plastic bag use" or new plastic bag of the future.

MATERIALS:
- Assignment handout, Google docs and laptops, list of recyclable plastics by the numbers, videos from Youtube: "The shopping cart project- IDEO", and "How it's made: plastic bags"

LIST OF HANDOUTS
- Assignment handout, plastics reference for students' engineering notebooks

BACKGROUND INFORMATION:
Use of plastic bags for packaging is a 21st century need, but it has many downsides. Some plastics are petroleum based, and thus from a non-renewable source. Some plastic polymers can be toxic to humans and harmful to the environment when they breakdown. Some towns even ban or limit their use. This is an issue that can be addressed using engineering design.

CLASSROOM ACTIVITY DESCRIPTION (LABORATORY/EXERCISES/PROBLEMS) including detailed procedures: (3-5 days)
This lesson requires students to become familiar with a large amount of new information, including the history of plastics, all possible uses of plastics bags, the coding systems for plastics, safety, manufacture, etc. so students work in teams of two or three using a Google doc to record thoughts and research, which they share with the teacher.
1) The project starts with IDEO "Shopping cart project" video, where a team re-thinks a common object, the shopping cart, using engineering design method, and applies this to the plastic bag.
2) In teacher guided/assisted discussions they build a "knowledge base" of information about plastic bags through brainstorming. They complete their "knowledge base" and answer outstanding questions through on-line research. They include a reference list.
3) Students build a table or bullet list of "pros" and "cons" based on the information in their "knowledge base" based on what's good or bad about how we use plastic bags. Some information might be in both columns.
4) Based on their brainstorm information and "pros and cons" table, students propose a plan for the future of the plastic bag. It can be a plan to replace, reformulate, or recycle, or change the way plastic bags are currently used. It must be drawn from the information the students have gathered.
Extra Credit: Imagine an unintended consequence or side effect of their plan.

SAMPLE QUESTIONS TO ELICIT CLASS DISCUSSION:
What is a plastic?
What is involved in the lifecycle of a plastics? in particular, the plastic bag?
What is meant by recyclable, biodegradable or compostable, when describing plastics?
How do we use plastic bags? are there "bag" and "non-bag" uses?
Are there safety issues? Environmental consequences?
Are there alternatives to petroleum based plastics?

HOMEWORK ACTIVITY/EXERCISES/PROBLEMS:
complete the Google doc and share it with the teacher

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:
See rubric in teacher notes

REFERENCES:
- IDEO Shopping Cart Project: https://www.youtube.com/watch?v=taJOV-YCieI
- How it's made, plastic bags: https://www.youtube.com/watch?v=8CfL5xl2N1Q
- California bans plastic bags: http://www.sfgate.com/politics/article/California-becomes-first-state-to-ban-plastic-bags-5791041.php
- Bioplastics Magazine: http://www.bioplasticsmagazine.com/en/index.php

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MODULE TOPIC: Polymers for Packaging - Lesson 2 - Making bio-plastic film - comparing recipes 1-2days

STANDARD(S) & INDICATOR(S):
HS-ETS-2 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

OBJECTIVE(S): Students will be able to:
Create a "plant-based" plastic.
Evaluate its properties and compare them to petroleum based plastic bags.

MATERIALS:
- Recipe for starch based plastics,
- measuring spoons,
- hot plate, soft spatula for stirring,
- small pot or large beaker,
- corn starch, potato starch and tapioca starch, (any store brand corn starch will do, Bob's Red Mill is a good source for potato and tapioca starch)
- white vinegar, glycerin or vegetable oil.
- aluminum foil or non-stick baking paper, and a rolling pin to make plastic film.
- petroleum based plastic bags for comparison, #2 and #4

LIST OF HANDOUTS
1) Notes to Teacher
2) Recipe and instructions for students
3) Sample lab: "Make it and Break it, Bioplastics from Starch

BACKGROUND INFORMATION:
- patents on biodegradable or compostable plastic bags - at least 14 listed in FreePatentsOnline. example: http://www.freepatentsonline.com/20040241359.pdf - 2004 patent for biodegradable plastic bag.

CLASSROOM ACTIVITY DESCRIPTION (LABORATORY/EXERCISES/PROBLEMS) including detailed procedures:
There are dozens of recipes and Youtube videos on how to make bioplastics from starch. The typical recipe uses starch, water, glycerin or vegetable oil, and white vinegar, and heats them to form a smooth clear paste which can be molded and cooled in a shape.

The starch used in this bioplastic recipe may be varied to produce possibly different properties in the plastic films. Students will try one or all of the various starches. When shaping the starch plastic into a film, students should shape the film into a form that could be compared to a bag. Students will then design tests to compare their biofilm bag to a petroleum based plastic bags. When designing a test students should think about how to "standardize" their test, so it can produce comparable results when the recipe is repeated at a later time, for example, the bioplastic bag must be able to hold a certain amount of warm water without leaking, or must be able to hold a certain mass without deforming. Students can also compare qualitative properties, for example, how easily the material can be cut with a pair of scissors. .

SAMPLE QUESTIONS TO ELICIT CLASS DISCUSSION:
How is a plant based plastic made?
How could this process be scaled up to an industry?
How does a bag made from bio-plastic compare to petroleum based bags? and how could I test the ones I can make to determine this?

HOMEWORK ACTIVITY/EXERCISES/PROBLEMS:

Lab report - rubric in teachers notes

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:

Rubric in teacher notes

REFERENCES:
- Patent search on biodegradable plastic bags: http://www.freepatentsonline.com
- Make your own bioplastic: https://www.youtube.com/watch?v=5M_eDLyfzp8
- Bioplastics Magazine: http://www.bioplasticsmagazine.com/en/index.php
- Three students from Thailand win the $50,000 prize for a new bioplastic made from fish scales https://student.societyforscience.org/article/kids%E2%80%99-ingenuity-honored-intel-isef

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Engineering Challenge: Rethink the plastic bag and bioplastics lab Teachers notes and rubrics

These two lessons focus on the engineering aspects of plastic.

Lesson 1

Plastic bags are ubiquitous. They meet a need with convenience. They also have a number of drawbacks, plastic is a petroleum product, the bags can be a major source of pollution, there are safety issues, some are difficult to recycle and some towns have passed laws banning their use. Using engineering design students will "re-imagine" the future of the plastic bag.

1) Start with ordinary bags from the supermarket, and have students look for the recycle numbers and safety warnings. Explain that the number system was developed by the Society of the Plastics Industry, SPI, as the "SPI resin identification coding system" developed in 1988, in order to facilitate identification and recycling of plastics. Plastic bags are typically #2 or #4 in the coding system.

2) Have students brainstorm to think of every way we use plastics bags, and every problem that they might cause. For some of the questions and topics that arise have students search the internet for related articles and supporting information that can answer their questions, and build a reference list. Have students jot their a google doc shared with the members of their team and the teacher. This way you can monitor progress while making rounds to the different teams in the classroom, and offer students suggestions and timely feedback.

3) As students are doing their brainstorm and info search some topics may be missed, for example, students may not find the info on bioplastics, or they may not know that there are several patents on starch based plastic bags, which include information on their formulas and the manufacturing process.

Rubric for grading

Part 2 1-3 pages, 50%
40-50 Students have created widely varied lists of how plastic bags are used in everyday life, They have information on the history of the plastic bag and the societal need for it. They explain the chemistry of the plastic bag, that both #2 and #4 are polyethylene, and that it takes almost forever to degrade and decompose in a landfills. They mention the impact on the environment and have some information on how that are or can be recycled. They also have a reference list of their sources.
30-40 Students are missing at least one of the information aspects, or mention it only in passing, of the knowledge base about plastic bags. Their refenence list is missing or incomplete.

20-30 Students are missing at least half of the knowledge base they could have gathered, and ,might not have any references.
0-20 Students define the case for the plastic bag only superficially, and might have no references.
Part 3 - up to one page, 30%
20-30 Students have a table or bullet list of pros and cons that link directly to the facts in their knowledge base
10-20 The students' list is short compared to the knowledge base, and some items may not come from the knowledgebase.
0-10 The students' list is short and trite, and may have little to do with the information in their knowledge base.

Part 4- up to one page, 20%
15-20 Students have a thoughtful proposal that is based directly on trends in their knowledge base and the pros and cons in their summary. It may have more than one action point.
10-15 Students have a proposal that is based at least in part on the facts in the knowledge base, but it may lack creativity or possibility.
0-10 Student solution is trite and not based only on their information in their knowledge base.
Extra credit: 5-10 points,
This can only count if students describe a true "unintended" consequence, not an intended one. It can be good or bad. For example, if a student suggests a offering a premium of returning plastic bags, similar to that of recyclable bottles, it may create a new cottage industry. There might be fundraiser plastic bag drives like paper drives. Bioplastics may have an impact on the food industry.

Lesson 2

Making bioplastics

In this lab student follow a very simple recipe for starch based plastic and vary prepare a series of batches varying the type of starch, corn starch, potato starch and tapioca starch. They will prepare flat and shaped plastic films that can be compared to each other, and to petroleum based plastic bags. They will also design qualitative and quantitative measures to evaluate their films.

Bioplastics can be made from a number of organic materials, usually starches, but some are made from dairy products, natural fibers, and even fish scales. The beauty of a bioplastic item is that, unlike petroleum based plastics they are short lived, and break down to compostable byproducts.

Many bioplastic products are out on the market, such as "compostable" plastic cutlery. A quick search of www.freepatentsonline.com will turn up over a dozen recent patents on biodegradable plastic bags.

Bioplastics are usually classified as SPI code 7, "other" which also include new plastics used in 3D printing such as PLA, polylactic acid, and ABS, acrylonitrile butadiene styrene.

All starch based bioplastic recipes include the same basic ingredients which are heated and stirred into a gel that can be shaped: water and starch, a softener, glycerin or vegetable oil, and a mild acid, usually white vinegar, or dilute HCl.

Rubric - Grading the lab

Laboratory work - up to 40%
The student has produced at least 2 samples of each of the bioplastics and has prepared samples of the petroleum based plastics to compare. The samples are of consistent quality and can be tested.

Qualitative Evaluation - up to 10%
The student has a list of all observable properties, color, texture, flexibility, ability to be cut, etc.

Initial Quantitative Evaluation - up to 10%
The student has a consistent set of mass and surface areas in a usable form to show any trend

Test Design and results: - up to 20%
The student has a useful and repeatable test that can be used to compare plastic samples, for example, the amount of weight the plastic can support before it distorts, or the amount of distortion, measured by how much it stretches, when poked with a pencil point before it is pierced by the point.

Discussion questions - 5 points each
Students answers must reflect the work they have done in testing.

Engineering Challenge: Rethink the plastic bag

Part 1: Video: "Ideo Shopping Cart Project"
observe the use of Engineering design
- IDEO Shopping Cart Project, https://www.youtube.com/watch?v=taJOV-YCieI

For the next step you may use the laptops in the classroom. Record ideas in your engineering notebooks, and share a google doc with the teacher containing your on-line research and report.

Part 2: Define and frame the challenge: brainstorm ideas - no judgment
Record all your team's thoughts and add references from your literature search.
Questions that must be addressed:

- What is the purpose of plastic bags or plastic wrap?
  - Define as many uses as possible
  - What is the societal need for a plastic bag?
  - Are there "non-bag" uses for plastic bags?
- What are plastic bags, and like materials, like plastic wrap, made of?
  - include something about their chemistry
- Where do the materials come from and where do they go? recycling?
  - What is the history of the plastic bag"
  - What is the environmental impact of using plastic bags/wrap?

references:
- How it's made, plastic bags, https://www.youtube.com/watch?v=8CfL5xl2N1Q
- "Plastics by the Numbers"

Part 3: Prioritizing information: Based on your brainstorm, build a table of pros and cons for the use of plastic bags, include the topics of personal and environmental impact, and chemistry.

Part 4: The prototype: The plastic bag re-imagined - your proposal on how the plastic bag could be remodeled, recycled, or replaced. Describe the impact on society.

Reporting requirements - notebooks and google doc.
Your report must include:
- A summary of your brainstorm and literature search, 1-3 pages, 50%
- A bibliography of your literature search
- A table of pros and cons for the current version of the plastic bag,(1 page, 30%)
- Your team's idea for the plastic bag - re-imagined - and your reasons why this is its future. (1 page 20%)

Extra credit: Describe an "unintended" consequence or side effect of your proposal.

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Bioplastics Lab

Name _____ Date _____

Objective: Create sample plastic films from three variations on a starch plastic recipe and design a testing scheme to compare them to each other and to petroleum based plastic bags.

Materials:
recipe and measuring spoons
1 tablespoon of starch (potato, corn or tapioca)
4 tablespoons of water
1 teaspoon of glycerin
1 teaspoon of white vinegar
large beaker or small pot
hotplate and soft spatula
aluminum foil or non-stick baking paper
rolling pin

Procedure:
Blend the starch, water, glycerin and vinegar in the pot or beaker and heat slowly while stirring frequently. The mixture will thicken to the consistency of taffy and become clear. Transfer it to the foil or non stick paper and shape it into a film. A rolling pin on a top piece of tin foil may be used to smooth it. Make a set of samples for each type of starch.

Find some petroleum based plastic bags, #2 and #4 to compare your plastics, cut samples about the same size as you bio plastics

Evaluation:

1) Make a list of all the qualitative differences between your bioplastic and the petroleum based plastic, for example, color, texture, stiffness, and ability to be cut with a scissor
2) Make a table of the masses and estimated surface areas of each of plastic films, including samples of petroleum based plastic
3) Design a test, similar the tensile strength test in "Make it and Break it" include a standard that you can use to compare these plastic films to another batch in the future.

Discussion

- What qualitative differences in properties do you think can be attributed to the differences in formula? why?
- Describe the test you designed for bioplastics vs each other and petroleum plastics
- What quantitative measurements distinguish the plastics the most and why?
- What formula modifications might improve the properties of bioplastics?

http://salvenaturals.com/blog/?p=367

Plastic Recycling Symbols

		Typical Products	Recycled Products
1 PET	Polyethylene Terephthalate	Soft drinks containers Peanut butter jars	Pillow stuffing
2 HDPE	High Density Polyethylene	Milk or juice jugs Some yogurt containers Shampoo bottles	Blue Boxes Playground equipment
3 PVC	Polyvinyl Chloride	Water bottles	Floor tiles Bubble wrap Traffic cones
4 LDPE	Low Density Polyethylene	Bread and grocery bags	Plastic lumber Compost bins
5 PP	Polypropylene	Syrup and ketchup bottles	Ice scrapers
6 PS	Polystyrene	Foam cups	Egg cartons
7 OTHER	Other	Safety glasses Automotive tail lights	Outdoor signs

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