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Title: Trash to Treasure
Grade Level: 11-12
Subject Area: Mathematics (AP Statistics)
Duration: 3 days with collaboration from AP Biology
Setting: Classroom and Science Lab
Materials:

- Samples of used frying oil from 4 different restaurant chains
- NaOH
- MeOH
- EtOH
- phenolphthalein
- Flasks (or Gatorade bottles)
- Graduated cylinders
- Droppers
- Graduated test tube with rack
- Scale
- Spatula
- Rubber gloves
- Kim wipes
- Protective glasses
- Weighing paper

Back ground knowledge: Measurement, basic math skills, inferential statistics knowledge (tests for comparing proportions, checking assumptions, creating confidence intervals)

Summary:

- Students will "work" as chemical engineers for a company that produces biodiesel from reclaimed waste frying oil.
- Students will develop and test a hypothesis concerning random samples of oil received from 3 different random restaurants within 4 different chains of restaurants to determine if the differing amounts of %free fatty acid are statistically significant.
- They will perform a titration using phenolphthalein to determine the percent of free fatty acid that is in each sample.
- The samples will undergo transesterification to produce biodiesel and glycerol (a byproduct of the transesterification process). The amount of free fatty acid and glycerol will be recorded and graphed using %free fatty acid as the predictor, and amount of glycerol as the response.

- They will come up with 90%, 95%, and 99% confidence intervals regarding %FFA obtained from each gallon of Waste Frying Oil recycled.

- Their findings will be presented to the class using PowerPoint group presentations.

- Each student will turn in a written report showing and defending their findings.

Trash to Treasure

Grade Level: HS Math **Subject:** AP Statistics (11-12th grade) with collaboration with AP Biology **Prepared By:** Peggy Dunn

Duration: 3 days

Analyze Learners

Overview & Purpose (STEMcinnati theme)

Overview: Finding alternatives sources of fuel is very important in today's world for financial, political and ecological reasons. One source that is already being used is biodiesel. One option for producing biodiesel is through converting waste frying oil (WFO), a substance that already exists, into biodiesel fuel. The quality of this waste oil varies and determines the amount of catalyst needed. If too much catalyst is used, then the cost is increased; if too little catalyst is used, then all of the potential fuel won't be converted. This lesson is designed to help students see how real world problems are solved using mathematics. They will collect samples of WFO from various local sources (restaurants) and determine the optimum amount of catalyst needed for the transesterification (conversion) of the used oil. They will also come up with a model that relates the percent of free fatty acid (FFA) and the amount of glycerol produced. After performing the transesterification in the science lab, they will measure how much biodiesel and glycerol are produced and come up with a hypothesis test to see if there is a statistically significant difference in the % of FFA in the samples gathered from the restaurants. They will graph and compare proportions of the glycerol (a bi-product of the transesterification) to the amount of biodiesel created and come up with a confidence interval of all transesterification of waste frying oil into biodiesel. Their findings will be presented to the class along with a PowerPoint presentation.

A: This lesson has broad applications in the areas of performing experiments and collecting and analyzing data, necessary skills for many fields including scientific research, engineering, business applications, and solving problems.

C: This lesson helps students learn to investigate potential solutions to real world problems. It also helps them to realize that they are capable of learning to solve these global pressing issues through the application of the math and science skills they are learning. This lesson helps students learn to "think like an engineer."

S: Solving the fuel crisis is of paramount importance along with finding alternate renewable sources of fuel. This seems overwhelming but students will begin to realize that they have the necessary tools to work toward the solution. In this case, the waste product is already there, and finding ways to reduce, reuse, and recycle this "trash" into a useful "treasure" is a way of thinking that must be encouraged.

Education Standards Addressed

NCTM:

- organize and consolidate their mathematical thinking through communication
- recognize and apply mathematics in contexts outside of mathematics.
- formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them;
- select and use appropriate statistical methods to analyze data
- develop and evaluate inferences and predictions that are based on data

Kentucky Core Content:

- MA-HS-4.3.2
  Students will design simple experiments or investigations to collect data to answer questions of interest.
- MA-HS-4.1.1
  Students will analyze and make inferences from a set of data with no more than two variables, and will analyze problems for the use and misuse of data representations.
- MA-HS-4.1.2
  Students will construct data displays for data with no more than two variables.

Select Goals and Objectives	**Teacher Guide**	**Student Guide**	
Goals and Objectives	**Goals: Students will be able to apply mathematical procedures and inferential statistics to answer real world problems. They will communicate their finding using several media forms.** **Objectives:** • **Students will analyze samples of WFO (Waste frying oil) to determine if there are significant differences of free fatty acids** o **Students are responsible for setting up hypothesis test and determining which design they should use** o **Students will analyze results and made a decision** o **Students will communicate results using two forms of media**		**Materials Needed** • Samples of used frying oil • NaOH • MeOH • Flasks (or Gatorade bottles with lids) • Scale • Spatula • Rubber gloves • Kim wipes • Protective glasses • Weighing paper • microwave
Select Instructional Strategies – **Information**	Check to make sure students are checking assumptions (cannot assume population is normal) and must choose which test to use for hypothesis test accordingly. More catalyst won't increase yield after a certain point. There is an optimum amount.		
Utilize Technology	Ti-84, computer with digital projector, excel, mobi interwrite pad		**Other Resources** (e.g. Web, books, etc.) Fuel Alternative Video

Require Learner Participation **Activity**		Small Group work: oil analysis, titration, transesterification and hypothesis test Individual Work: Collect oil from restaurant and analyze results. Write paper to turn in. Small Group work: Disseminate results of oil analysis for class presentation.	
Evaluate (Assessment) (Steps to check for student understanding)	Most of this activity is group based work. Each student must turn in their own paper, written in their own words.		**Additional Notes**

Important Attachments:

1. Pre-Post Assessment
2. Worksheets
3. PowerPoint
4. Reflection after lesson