Life Cycle Assessment and Renewable Energy from and Indigenous Perspective

ND EPSCoR Lesson Plan

Lesson Title: Life Cycle Assessment and Renewable Energy from and Indigenous Perspective

Lesson Overview: This lesson focuses on ways of reclaiming sustainability as an in Indigenous way of knowing and focuses on the western science concepts of energy from wastes and life cycle assessment. Students will explore how chemical engineering concepts allow for us to take the idea of converting food (traditional corn ethanol) into fuel and how we should be looking at converting waste materials into fuel as well. The first part of the lesson focuses on how engineering can be used to help make use of "waste" sources. This second part of the lesson introduces students to life cycle assessment. In this lesson, students will consider what raw materials and energy that went into our lunch. In addition, students are tasked with considering ways in which the these resoucrces can be reduced using indigenous knowledge.

Topic(s): Chemical engineering, biofuels, food production and food waste, energy conversion, sustainability

Grade or Grade Band: 6-8

Lesson Objectives:

1) Students recognize how indigenous knowledge and ways of knowing are embedded within engineering.
2) Students explain where the resources and energy we consume everyday come from within in a life cycle assessment context.
3) Students compare and contrast food production and food waste and develop creative solutions to using earth's resources in a sustainable way.

National Next Gen Standards:

- MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

North Dakota Standards:

- MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

- MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Time Needed (estimate): Two 50 minute sessions

Lesson Author: Brittany Hagen
Dr. Brittany D. Hagen is an Associate Professor of Education and CAEP Accreditation Coordinator at Mayville State University in Mayville, ND. Dr. Hagen teaches courses related to foundations of education, educational technology, educational assessment, and elementary methods. Additionally, she has developed both online and classroom curriculums for a variety of age groups, including teach-the-teacher programs, assessment data modules, and high school aviation facilitator guides and interactive student activities. Dr. Hagen is also a proud Mayville State alumnus, dedicated to developing highly effective teachers who share a passion for educating young learners.

Scientist/K12 Collaborator & University: Bethany Klemetsrud, University of North Dakota

Scientist Bio/Reserach: Dr. Bethany Klemetsrud is an assistant professor in Chemical Engineering at the University of North Dakota. Bethany grew up on the White Earth Nation and is excited to be able to work close to her home and family. She received her undergraduate degree from the University of Minnestoa Duluth and completed her PhD at Michigan Technological University in 2016. Her dissertation is titled "EXPERIMENTAL AND THEORETICAL INVESTIGATION OF SUSTAINABLE FAST PYROLYSIS BIOFUELS FROM WOODY BIOMASS". Her passions include advocating for the broadening participation of Native students in STEM, developing technologies that can convert waste into useful products or energy. Beth's primary form of research within the chemical engineering department looks at using fast pyrolysis to thermochemically convert waste materials into use chemicals and energy dense products. Bethany comes from a large family and is committed that her younger siblings and niece and nephews be able to see themselves at Scientists and Engineers if that's what path they choose.

This work focuses on developing renewable or sustainable energies from materials from agriculture and municipal wastes. This work employs biochemical and thermochemical solutions. Due to the dangers of thermochemical in a high school setting we will focus on biochemical conversion. All renewable/sustainable energy must be evaluated in terms of its ability to solve climate issues. This can be done mathematically with life cycle assessment. Measuring all of the inputs and outputs of a system from extraction to final use and disposal of that product or process. This work looks at novel solutions for turning waste into energy and evaluating it at a much larger scale of sustainability. Life cycle assessment will be used to quantify environmental impacts however the use of stakeholder and community participations will look at the larger question of sustainability and if these sources of energy are beneficial to communities in terms of social and economic impacts.

Preparation/Materials

Background knowledge students must have to be successful: Students will need to have some background knowledge on energy and how the molecules in food are rearranged, through chemical reactions, when consumed.

Differentiation and accommodation to support learning for all students:
When designing any lesson, it is important to address the needs of all learners. Please refer to the following resource for ideas on how to adjust your lesson to accommodate your students' particular learning needs: https://www.understood.org/en/learning-thinking-differences/treatments-approaches/educational-strategies/common-classroom-accommodations-and-modifications

Essential Terminology

Biochemical – use chemical reactions to break apart biomaterials.

Biofuels – naturally derived material used to produce energy and heat

Biomass – animal or plant material used as fuel

Chemical engineering – a discipline of study that transforms raw materials into a usable product or energy

Life cycle assessment – the analysis of environmental impacts on a product during its life cycle

Sustainability – meeting current needs while being cognizant of future generations and their ability to meet needs.

Resources:
Experiment materials, powerpoint, graphic organizer, worksheets

Websites: Embedded in lesson plan and PowerPoint

Materials needed:
- Erlymeyer flasks
- Yeast
- Sugar
- Corn syrup
- Corn flakes
- Balloons
- White boards
- Index cards
- Lesson specific worksheets

PowerPoint – found as separate attachment

Procedure/Activities

Lesson 1: How to convert sugars into energy (50 minutes)

Engage:

1. Write the words "chemical engineering" on the board. Ask students to come up in small groups or one at a time and list everything they know about chemical engineering. The list may be brief. Review "What is chemical engineering?" with students (PPT Slide 2).

Explore:

2. Review the Renewable Energy graphic with students (PPT Slide 3) highlighting the biomass energy circled in red. Consider discussing other forms of renewable energy found on the graphic.
3. Write the word "biofuel" on the board. Have students turn and talk to discuss what the word "biofuel" might mean and how it relates to chemical engineering and renewable energy. Review the definition of biofuel and discuss some examples with students (PPT Slide 4). Continue discussing why biofuels are used (PPT Slide 5) and how they are produced (PPT Slide 6).

Explain:

4. Use the graphics and information found on PPT Slide 7 to explain what pyrolysis is to students. Consider printing the pictures on slide 7 and asking students to put them in order.
5. To describe the production of biofuels, give students a blank graphic organizer that matches the graphic found on PPT Slide 8. As you discuss each concept, have students add the information to their graphic organizer. Review recorded responses together to ensure accuracy.
6. Review biochemical fermentation (PPT Slide 9) and describe what yeast is (PPT Slide 10) so students can be successful with the experiments conducted and how the characteristics of yeast play a part in the conversion of energy.

Extensions for learning more about this topic:

7. In small groups, have students complete Experiment 1 (PPT Slide 11). Prior to students completing the experiment, review the questions on PPT Slide 12. When the experiment is finished, have students discuss the questions in their group and record them on whiteboards in preparation for a whole group discussion. Once all groups have completed the experiment and discussed the questions, lead a whole group discussion to answer the questions on Slide 12. Have students use information recorded on their whiteboards to answer the questions. Clear up misconceptions and highlight key concepts throughout the discussion.
8. Again, in the same (or different) small groups, have students complete Experiment 2 (PPT Slide 13). Prior to students completing the experiment, review the questions on PPT Slide 14. When the experiment is finished, have students discuss the questions in their group and record them on whiteboards in preparation for a whole group discussion. Once all groups have completed the experiment and discussed the questions, lead a whole group discussion to answer the questions on Slide 14. Have students use

information recorded on their whiteboards to answer the questions. Clear up misconceptions and highlight key concepts throughout the discussion.

9. To further debrief the experiments, review the Biomass Structures, Biochemical Engineering, What is an enzyme? Slides (PPT Slides 15-18). This information will also help provide background knowledge for Lesson 2.

Evaluation of learning (formative or summative task)

10. Ask students to share aloud or in writing one thing that is still unclear about how to convert sugar biofuels and converting energy. Consider discussing the unclear topics with students at the end of this lesson or the beginning of the next.

11. Conclude the lesson by reviewing the key points on the Conclusion slide (PPT Slide 19).

Lesson 2: How to evaluate the sustainability of a process and products?

Engage:

1. Hand an index card to each student. Have them write the sentence starter "Sustainability is…". Have them pass their index card one person to the left or right. With a new card in hand, have students complete the sentence starter with one thing they know about sustainability. Again, have students pass their cards to the next person and add another sentence related to what they know about sustainability. The cards can get passed a few more times or the activity can end here.

Explore:

2. Have students read some of their cards aloud. Consider writing down the common ideas that appear on several different cards. Discuss the common ideas and highlight key information from the discussion.

Explain:

3. Review the What makes something sustainable? slide with students (PPT Slide 21). Also review the Life Cycle Assessment graphic with students (PPT Slide 22) and the medicine wheel on PPT Slide 23.

Extensions for learning more about this topic:

4. In this lesson, students will consider what raw materials and energy that went into our lunch. Have students work individually or in small groups to complete the Food Production Worksheet based on what they ate for lunch that day (or the previous day). Consider guiding students through the first few prompts and demonstrate how to use the food emissions calculator found at: https://www.foodemissions.com/Calculator
5. Use the question prompts on PPT Slides 24 and 25 to guide discussions about food production, comparing foods, and energy conversion.
6. Further examples include: What energy went into the walleye we caught and ate, what energy goes into the manoonim we harvested and prepared, what energy comes from the picking of berries or the drying of sage? Discuss bison or deer (depending on tribes) and how all parts were used. There was no such thing as waste in indigenous culture. Discuss the effects of traditional fuels and how scientist came up with using our food as a fuel.
7. In the same small groups, have students complete the Food Waste Worksheet based on the waste that came from lunch that day (or the previous day). Consider guiding students through the first few prompts and assist them with using the stop waste calculator at: http://www.stopwaste.co/calculator/
8. Use the question prompts on PPT Slide 26 to guide discussions about food waste and how to reduce it.
9. Continued discussions on carbon footprint and food emissions should be had with students and can be found on PPT Slides 27-29.

Evaluation of learning (formative or summative task)

10. Pose this question to students: "Based on what you learned in this lesson, what are things we can do to help creation?" Record their ideas on the board or just discuss them informally. Share the list of possible ideas from on PPT Slide 30.
11. To assess students' learning, ask them to write the answers to the three sustainability trivia questions on their whiteboards or do an informal check for understanding using the questions (PPT Slides 31-33).

Additional Lesson Resources / Materials

References:
None

Websites for purchasing materials
None