Sustainability Practices in Modern Farming

High School Digital Lesson Educator Guide

Lesson Overview

With an ever-growing population and limited availability of resources and farmland, farmers and ranchers have had to adopt more sustainable agricultural practices. Since sustainability can be defined in many ways, for purposes of this lesson, students will establish a working definition of sustainable agriculture. Then, students will brainstorm the types of applications, measurements or tools that can help farmers and ranchers become more sustainable. Furthermore, students will work in teams to identify a problem/need in modern agriculture and conduct more in-depth research on the topic. Lastly, they will follow the engineering design process to develop and test an innovative idea for a prototype that can help farmers and ranchers become more sustainable.

Duration: 90-120 minutes

Content Areas: Earth Science/Environmental Science

Grade Level: Grades 9-12

National Standards:

Next Generation Science Standards (NGSS)

- **HS-ESS3: Earth and Human Activity**
  - Students who demonstrate understanding can:
- **HS-ESS3-4:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Disciplinary Core Ideas:

- **ESS3.C: Human Impacts on Earth Systems**
  - The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources (HS-ESS3-3)
  - Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation (HS-ESS3-4)

Standards for Technological Literacy – International Technology and Engineering Educators Association (ITEAA)

- **Standard 5: Students will develop an understanding of the effects of technology on the environment.**
  - **G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.** For example, water treatment and filtering technologies can facilitate the reuse of water; wind and erosion can be reduced by no-till farming; and aluminum containers can be recycled.
  - **J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.** For example, a building can be strategically oriented to the sun to maximize solar gain, and biodegradable materials can be used as compost to make the soil more nutrient rich.

Essential Questions:

1. How do we define sustainable agriculture?
2. What modern practices and technological advancements have improved or have the potential to improve agricultural sustainability?
3. What steps need to be taken to design a solution to a modern agricultural need or problem?

Materials:

- Computers connected to the Internet
- Copies of "Think-Pair-Share Capture Sheet"
- Copies of the "8 Step Engineering Design Process"
- Engineering journals for each student, such as a marble notebook or a scientific notebook
- Copies of the "Extension: Writing Prompt"
- Copies of the "Sustainability Practices in Modern Farming Capture Sheet"

Objectives:

- Define sustainable agriculture
- Describe modern practices and technological advancements farmers and ranchers use to improve agricultural sustainability
- Design a solution to a modern agricultural need or problem following a systematic engineering process.

Background Information:

During the first day of the lesson, students will describe the most salient characteristics of agricultural sustainability and establish a working definition. In the process, they will consider what it means when people say farms are being "teched" up. Next, students will brainstorm different types of applications, measurements, or tools farmers and ranchers use to become more sustainable and summarize their ideas in a capture sheet. Lastly, students will work as part of an engineering team to identify a problem/need in modern agriculture and investigate the underlying context through more in-depth research. They will document their chosen problem/need and the results of their investigation in an engineering journal.

During the second day of the lesson, students will be using research recorded in their engineering journals to complete the remaining steps of the engineering design process to: develop possible solutions, select the best solution(s), design/construct a prototype, test/evaluate the solution(s), communicate the solution(s), and redesign the prototype. Information related to these steps of the engineering design process will be documented in the students' engineering journals. As an extension, students will address the premise that sustainable agriculture is a journey, not a destination in a writing prompt.

Procedure:

Day 1 (Slides 1 - 7)

Slide 1:

- As an activator, and to establish the context for the lesson, show the video, Climate Smart Farming Story (Fishkill Farms) from the Cornell Institute for Climate Change and Agriculture (CICCA):
  Link to Video:
  http://www.cornell.edu/video/fishkill-farms-climate-smart-farming
  Strategy:
  - Play the video and invite students to take notes. They should focus on writing down items that support the big idea of the segment.
  - After the segment concludes, provide students one to two minutes to write down five ideas that are important in understanding the segment, using key words and phrases.
  - Next, provide students two minutes to discuss their list with a partner.
  - Provide an additional two minutes for students to combine their lists into one list of six-seven words or phrases.
  - Provide students with two additional minutes to write one sentence summaries of the video.
  - Have students share their summaries with the class.

  Anticipated summarites include:
  - Extreme weather and climate variability can have significant impacts on farms
  - In order to spread risk, farmers plant multiple successions of the same crop
  - Farmers also use soil working techniques and specialized irrigation systems/drip lines with diversified water sources that have the potential to irrigate an entire farm
  - Green houses are also utilized to grow a portion of the crops. Small fruit crops are also grown under high tunnels. Both green houses and high tunnels protect the crops from the elements and provide for an extended production season by regulating temperature variation and rainfall.
  - New varieties of crops are grown for adapting to climatic change.
  - It is vital for farmers and ranchers to keep close control of what is grown on the farm and how it is grown through improved management strategies.

Slide 2:

- Review the lesson objectives and provide some background for the 2-day lesson.

Slide 3:

- After the first video, pass out the "Think-Pair-Share Capture Sheet."
- Give students an opportunity to complete the first column of the capture sheet for the first two questions individually. Then, invite students to share their responses with another student in order to complete the second column for the first two questions. As a pair, students should decide what they will share with the rest of the class.
- Call on students to share their answers to these questions using equitable calling strategies.
  Anticipated responses include:
  - Sustainable agriculture can be defined as the production of plant/animal food/products using farming techniques that protect public health, human communities, the environment, and animal welfare.
  - Show the three-legged stool image to emphasize the different dimensions associated with agricultural sustainability (economy, social equity, and environment). The economic leg involves such factors as infrastructure, security, fair trade/wages, and good jobs. The social equity entails working conditions, health services, educational services, community/culture, and social justice. Lastly, the environmental leg deals with issues such as renewable energy, conservation, restoration, and pollution/waste.
  - Important goals of agricultural sustainability include: conserving water, using renewable energy, reducing the use of fertilizers/pesticides, promoting economic stability of farms, promoting biodiversity of crops grown and the ecosystem, and improving farming

techniques (such as crop/livestock integration, reduced tillage, nutrient recycling, restoring natural habitats, etc.)

Slide 4:

- Next, share the following videos with students:
  - https://www.nsf.gov/news/special_reports/science_nation/leafsensor.jsp
  - https://www.nsf.gov/news/special_reports/science_nation/suprasensor.jsp
- Give students an opportunity to complete the first column of the capture sheet for the last two questions. Then invite students to share their responses with another student in order to complete the second column for the last two questions. As a pair, students should decide what they will share with the rest of the class.
- Call on students to share their answers to these questions using equitable calling strategies.

Slide 5:

- Next, pass out the handout, "8 Step Engineering Design Process" and the students' engineering journals.
- Tell students that they will be working in small engineering teams to identify a problem/need in modern agriculture and to investigate the underlying context through more in-depth research.
- Place students into groups, review the handout, and let them know that their engineering journal will be collected at the end of the second class and should be professional-looking and include the following:
  - A well-organized table of contents
  - List of all students comprising the engineering team
  - Numbered pages with detailed and dated entries
  - Background information/explanations/illustrations for each step of the engineering design process on separate pages
  - A Critical Reflection

Slide 6:

- For the remainder of class, ask students to work in their engineering groups to begin their research using devices connected to the Internet. They will document their chosen problem/need and the results of their investigation in an engineering journal. At this point, they will have completed the first two steps of the engineering design process:
  - Step 1: What is the need or problem?
  - Step 2: How will you research the need or problem?

Slides 7:

- The following is a list of possible problems/needs with useful resources to guide the research process. The topics/resources can be printed and cut out for student groups to randomly select. Teachers can use the Google Classroom doc. or use another school-approved cloud service to post the research links below for groups to access. Distribute the "Sustainability Practices in Modern Farming Capture Sheet" to guide and organize student research.
  Suggested resources:
  - Utilize wind or solar energy as an energy source
    - https://www.nrel.gov/news/press/2017/national-wind-technology-center-begin-first-validation-wave-energy-conversion-device.html
    - https://www.nrel.gov/news/program/2017/nrel-partnerships-designed-to-make-wind-farms-more-productive.html
  - Integrate crops and livestock
    - http://csanr.wsu.edu/livestock-crop-integration/
  - Reduce or eliminate tillage
    - https://www.usda.gov/media/blog/2016/12/19/seeing-believing-soil-health-practices-and-no-till-farming-transform
  - Retain and recycle nutrients on the farm
    - http://www.extension.umn.edu/garden/fruit-vegetable/nutrient-cycling-and-fertility/

- 360-degree videos that highlight animal safety, health, and comfort inside a modern pig farm
  - http://www.discoveringfarmland.com/lessons/360-videos
- Preserve and restore natural habitats to protect water quality and support wildlife
  - https://www.epa.gov/hwp/healthy-watersheds-protection-initiatives
- Use of GMO technology to protect crops
  - http://sitn.hms.harvard.edu/flash/2015/good-as-gold-can-golden-rice-and-other-biofortified-crops-prevent-malnutrition/
- Provide education and recreation opportunities to members of the community
  - https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/people/partners/
  - http://sustainability.psu.edu/student-groups

Day 2 (Slides 8 - 11)

Slide 8:

- Instruct students to take out their engineering journals containing information uncovered during the first two steps of the engineering design process.
- As an activator, ask students to identify an interesting fact from or if they have any questions resulting from the preliminary phase of their research.
- After answering students' questions, have them reform the groups they established during the first day of the lesson.

Slide 9:

- Engineering teams will now complete the remaining steps of the engineering design process which are shown below.
  - Step 3: How will you develop possible solution(s)?
  - Step 4: How will you select the best possible solution(s)?
  - Step 5: How will you design a prototype?
  - Step 6: How will you test/evaluate the solution(s)?
  - Step 7: How will you communicate the solution(s)?
  - Step 8: How will you redesign the prototype?

Slide 10:

- Remind students that they will need to document their explanations/diagrams for steps 3-8 of the engineering design process in their engineering journals.
- Allow each team to report out the results of their work. Give each engineering team two minutes to communicate their identified need/problem and the solution they came up with to address that need/problem.
- Collect each student's engineering journal. Guidance on grading students' group work and engineering journals can be found using the resources shown below. These include suggestions for self-assessment, peer/team-assessment, and teacher-assessment. Generally, the journals should be graded for neatness/organization, content accuracy, inclusion of all required elements, and inclusion of illustrations/diagrams.
  - http://www.education.rec.ri.cmu.edu/products/cortex_video_trainer/lesson/media_files/Engineering_Journal_Rubrics.pdf

Slide 11:

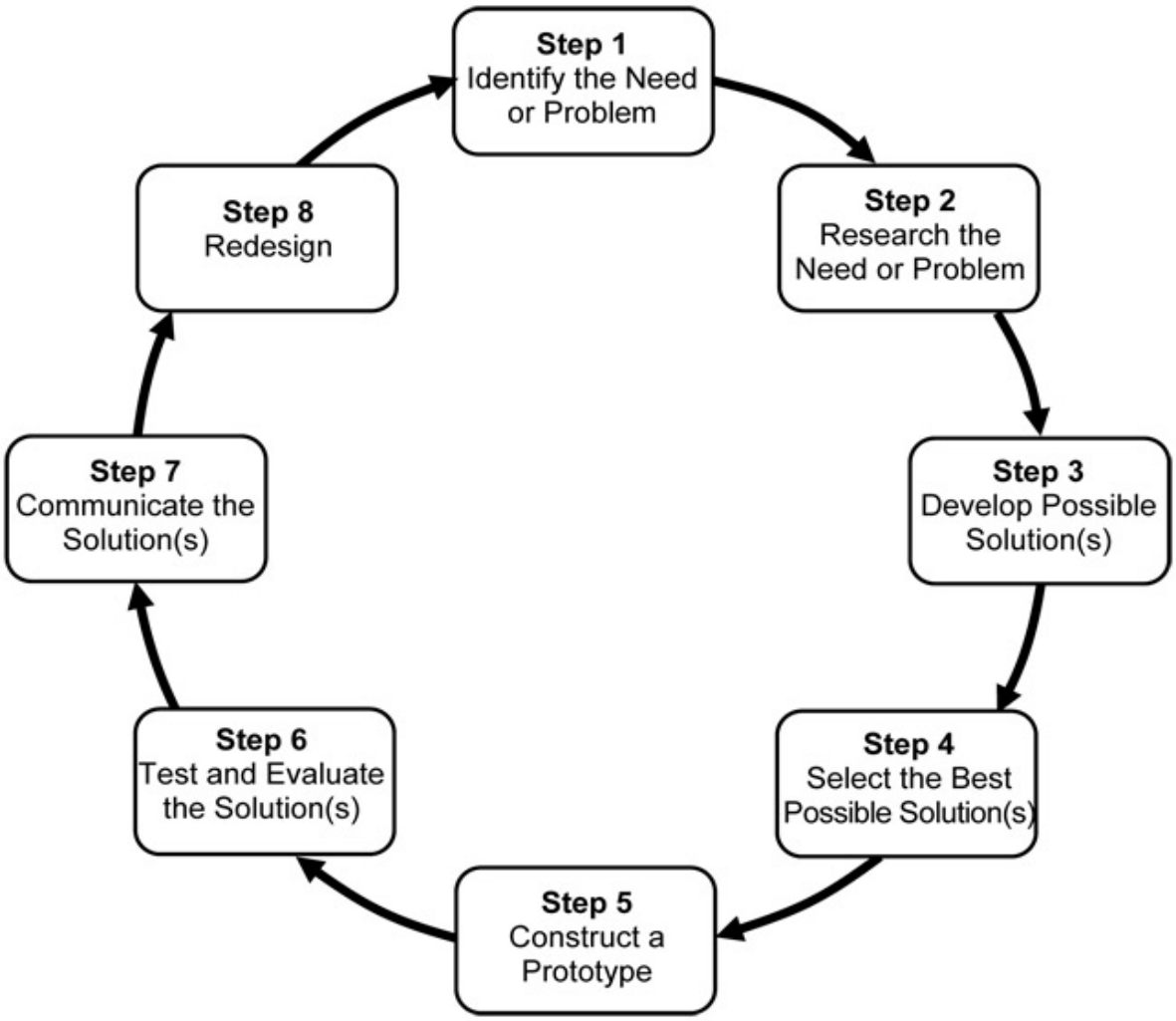
- Pass out the "Extension: Writing Prompt"
- As an extension to the lesson, students will complete a writing prompt in which they explain and comment on the premise that sustainable agriculture is a journey, not a destination.
- It is recommended that students spend a short amount of time for pre-writing activities (such as brainstorming, listing, free writing, clustering, mapping, or drawing).
- After they finish their prewriting activity, they should write their essay in the provided space on the handout. Remind students that a well-structured essay includes multiple paragraphs, smooth transition between ideas, precise language, and relevant details and examples from the sustainability lesson.

Name: _____ Partner's Name: _____ Date: _____ Pd. _____

THINK-PAIR-SHARE CAPTURE SHEET

Questions	What I Thought	What My Partner Thought	What We Will Share
How do you Define Agricultural Sustainability?			
What are Important Goals of Agricultural Sustainability?			
What does it Mean for Farms to be "Teched Up"?			
What are Applications, Measurements, or Tools Farmers & Ranchers Use to Become More Sustainable?			

8 STEP ENGINEERING DESIGN PROCESS



Source: **https://tinyurl.com/e-designprocess**

Name: _____ Date: _____

Extension: Writing Prompt

Write an essay in which you explain and comment on the premise shown below. Spend a short amount of time for pre-writing activities (such as brainstorming, listing, free writing, clustering, mapping, or drawing). After you finish your prewriting activity, write your essay in the space below. Make sure your essay is well-structured with multiple paragraphs, smooth transition between ideas, precise language, and relevant details and examples from the sustainability lesson.

Sustainable agriculture is a journey, not a destination.

Name: _____ Date: _____

Sustainability Practices in Modern Farming Capture Sheet

You will be working in small engineering teams to identify a problem/need in modern agriculture and to investigate the underlying context through more in-depth research. After selecting a problem or need, use the resources provided by your teacher to learn more. Capture your research in the table.

Topic:	
Problem/Need:	
Evidence	
Evidence	
Evidence	
Evidence	
Evidence	