Using Life Cycle Data to Help Teachers Understand Key Energy Concepts

DR K-12 PI Meeting

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BSCS

Energy: A Multidisciplinary Approach for Teachers (EMAT) online course

Partners

- Biological Sciences Curriculum Study (BSCS),
- Oregon Public Broadcasting (OPB),
- National Renewable Energy Lab (NREL),
- Great Lakes Bioenergy Research Center (GLBRC), and
- National Teachers Enhancement Network (NTEN) at Montana State University.

EMAT Materials Development Goals

Develop an online course for teachers

- Teachers who serve students from groups traditionally underrepresented in the sciences are our primary target audience
- Energy concepts within alternative energy contexts
- Constructivism enacted through the BSCS 5Es
- Situated cognition enacted through lesson analysis and two “lenses”
  - Science Content Storyline Lens
  - Student Thinking Lens

EMAT Materials Development Goals continued…

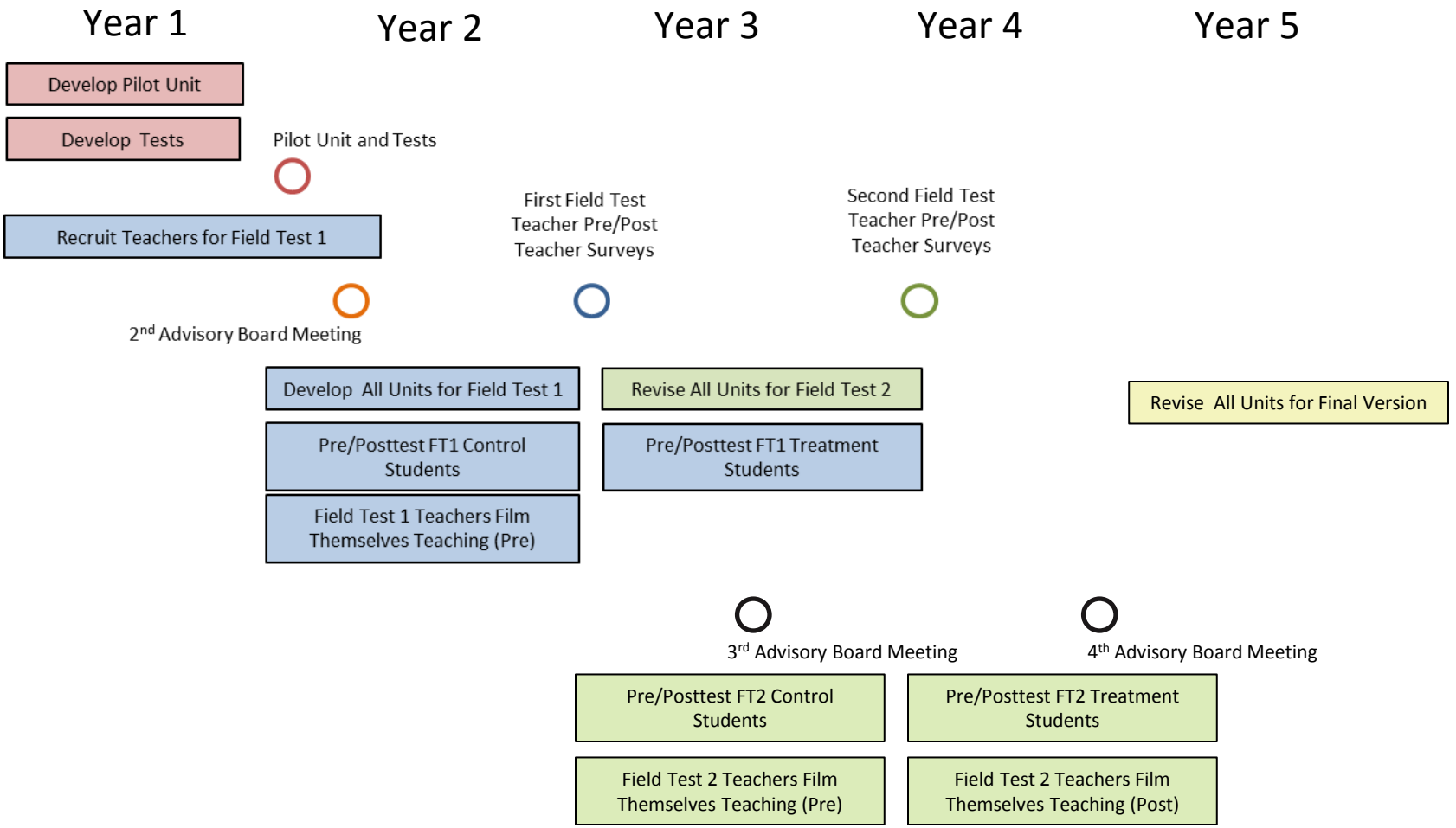
Take advantage of the affordances of a media-rich environment

- Interactive learning experiences
- Animations
- Classroom video
- Enhanced readings

EMAT Research Goals

- Understand the extent to which the online course enhances science teaching and learning
  - Teacher content knowledge
  - Teacher pedagogical content knowledge
  - Teacher practice
  - Student learning
- Identify the features of the course that were particularly effective
- Understand the strengths and limitations of the facilitated online format for lesson analysis PD

EMAT Project Timeline



Content Learning Goals
linked to NGSS crosscutting concept #5

1. Energy cannot be created or destroyed.
2. Energy transfers are never 100% efficient, some energy leaves the system as heat.
3. Tracking fluxes of matter and energy into, out of, and within systems helps one understand the system's possibilities and limitations.

Six Units Encompass the Three Content Goals

- Coal
- Nuclear Energy
- Wind
- Geothermal Heat Exchange
- Biofuels
- Solar

NREL Data and Interactive Learning Experiences

- Three experiences
- Purpose: To help teachers understand our third learning goal:

  Tracking fluxes of energy and matter into, out of, and within systems helps one understand the system's possibilities and limitations.

NREL Data and Interactive Learning Experiences

NREL has freely available life cycle inventory data (www.nrel.gov/lci/). NREL aims to

- maintain data quality and transparency.
- cover commonly used materials, products, and processes in the United States with up-to-date, critically reviewed LCI data.
- support the expanded use of LCA as an environmental decision-making tool.
- maintain compatibility with international LCI databases.
- provide exceptional data accessibility.
- be fully and sustainably supported, and
- support U.S. industry competitiveness.

NREL Data and Interactive Learning Experiences

Challenges associated with using NREL data:

- Data sometimes uses unusual units
  - e.g. “t*km” is a ton-kilometer, related to transporting materials by barge, rail, truck, etc.
  - Data are often incomplete
    - Making ethanol from corn doesn’t track oxygen produced by photosynthesis
    - Mining coal doesn’t track water flows
  - To conduct a life cycle inventory, it is necessary to daisy chain data sheets

NREL Data and Interactive Learning Experiences

Example

Life Cycle Inventory for producing ethanol from corn grain

- The system includes data sheets related to:
  - Growing the corn
  - Harvesting the corn
  - Processing the corn to make ethanol

LCI: Producing Ethanol from Corn Grain

- Used 12 data sheets in combination

  Ethanol, denatured, corn dry mill

  Corn wet mill, gluten drying

  Corn grain, at conversion plant

  Corn grain, harvested and stored

  Corn production, average

  Fertilizer, corn 2022

  Transport, combination truck, diesel powered

  Transport, train, diesel powered

  Transport barge, diesel powered

  Corn, wet milling operations

Creating LCI Interactives for Teachers

- We wanted to fill in data gaps through our own research and expertise
  - Account for oxygen and water as outputs from growing corn
  - Account for water in mining coal
- We wanted to present data clearly and cleanly so that teachers could analyze the possibilities and limitations of various energy systems using real data.

Introducing LCI Interactives to Teachers

- Teachers view an animation that describes the major features of the systems diagrams that they will encounter and be expected to create.
  - Inputs from nature
  - Inputs from the technosphere
  - Outputs to nature
  - Output products

http://onlinedev.bscs.org/course/view.php?id=99&page=10787

Introducing LCI Interactives to Teachers

- Teachers view an animation that highlights the key features of the systems interactives.

http://onlinedev.bscs.org/course/view.php?id=99&page=10814

- Guiding questions help teachers focus on the possibilities and limitations of the system.
  - especially useful when teachers are comparing and contrasting systems

Time to Try Interactives (~20 minutes)

Onlinedev.bscs.org

→ under development→ EMAT Field Test 2

Username: **bscsuser**

Password: **5415**

1. Coal → Explain→ Generating Electricity (scroll all the way to bottom of page)
2. Nuclear → Explain → Nuclear Energy: A Systems Perspective
3. Biofuels → Explain → Energy Inputs and Outputs

Questions while you explore

- Do you have any navigation difficulties?
- Are any data difficult to understand?
- What difficulties (if any) do you have?
- What possibilities do you see for using this interactive with high school students rather than high school teachers?
- How might teachers embed these interactives in a coherent instructional unit?

Some of what we found in field tests with high school science teachers…

- Coal
  - Not using data from interactive
  - Not interpreting data correctly (CO_2 vs. Coal)
- Nuclear
  - Not using data from interactive
  - Not thinking widely enough in terms of the boundary of the system (radionuclide waste)
- Biofuels
  - Not using data from interactive
  - Going outside of the bounds of the system (CO_2 from combustion of fuel)

Small Group Discussions

- What ideas do you have for enhancing the interactive learning experiences?
- How might the interactive learning experiences be made usable by high school students?
- How much guidance do teachers need in terms of analyzing data from interactives?
- How much guidance is too much?

Small Group Reports and Discussion

- What advice do you have for us?

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