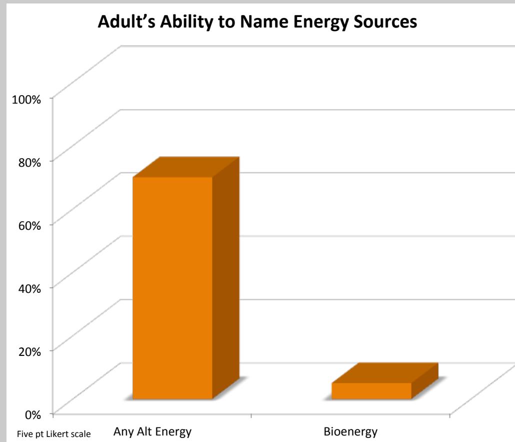
Using Bioenergy Science and Engineering to Integrate STEM Concepts: A Delphi Study

Brian D. Hartman, Kimi Grzyb, and Katherine G. Field

Conclusions and Recommendations

Based on feedback from bioenergy experts, we recommend that engineering concepts such as sources of energy, energy fundamentals, and the nature of engineering be included in science education curriculum. It is clear that engineering concepts are seen as a priority in bioenergy education (four of the top five concepts). This approach has the benefit of linking science education to engineering and thus to STEM (science, technology, engineering, and math) integration efforts. Science bioenergy concepts such as climate change, photosynthesis, chemical cycles, and ecosystems should also be integrated into existing science education curricula.



(Bittle, Rochkind, & Ott, 2009)

Introduction

Bioenergy is relatively unknown to the general public despite being the largest portion of all renewable energy sources in the United States. Only five percent (5%) percent of American adults were able to name a single renewable energy source in a recent survey (Bittle, Rochkind, & Ott, 2009). In order to improve students' understanding of energy concepts, it is important that the topic is included in multiple classes and at multiple levels throughout their K-12 experience. Because traditional energy concepts have typically emphasized the physical science side of energy production (Chen, Scheff, Fields, Pelletier, & Faux, 2014), students only cover this material when the curriculum calls for physical science study. If the biological side of alternative energy production was included in energy education, students would receive a much more broad energy perspective.

Goal

To develop a consensus of bioenergy expert views on what K-12 students should be taught about bioenergy.

Methods

- Three round expert Delphi Study with a panel of scientists, engineers, and educators participating in the Agriculture and Food Research Initiative (USDA) bioenergy program.
- Out of 84 panelists approached, 21 participated in the study and 9 complete all three rounds.

Findings

Concept	Mean*	SD
Energy Requirements Quantity and type of energy needed	4.88	.35
Energy Consumption Current and historical energy sources	4.88	.35
Climate Change Historical record and consequences	4.88	.52
Nature of Engineering Role of engineering in bioenergy	4.62	.52
Energy Fundamentals Work, energy, conversions	4.63	.52
Lifecycle Assessment Environmental impacts cradle to grave	4.50	.52
Photosynthesis How light energy is stored in plants	4.38	.46
Conversion Principles Types of conversions	4.38	.52
Chemical Cycles Water, carbon, nitrogen cycles	4.25	.35
Ecosystems Ecology and human impact	4.25	.52

*Five point Likert scale from 1=non-essential, to 5=essential

Importance

- Heavy emphasis on applied science (engineering) – Four of the top Five concepts (colored blue)
- Highlights value in understanding basic energy principles
- Includes key concepts linked to science such as photosynthesis and chemical cycles.
- Supports curriculum development
- Enhances teacher confidence in their ability to teach bioenergy – Many of the concepts are covered in traditional STEM classes
- Teaches principles of the sustainable bio-economy
- Aligned with NGSS (Next Generation Science Standards)

References

Bittle, S., Rochkind, J., & Ott, A. (2009). The Energy Learning Curve.

Chen, R. F., Scheff, A., Fields, E., Pelletier, P., & Faux, R. (2014). Mapping energy in Boston public schools curriculum. In Chen, R. F. et al (Eds), Teaching and Learning of Energy in K – 12 Education (pp. 135–152). New York: Springer.