Learners' understanding of energy: Conservation of amount, decrease of value

Abigail R. Daane, Lane Seeley, Amy D. Robertson, Stamatis Vokos, Rachel E. Scherr – Department of Physics, Seattle Pacific University

Theory

Quality learning connects formal knowledge to real-world experiences

- ✓ Students should view science learning as a process for understanding real phenomena, not memorizing a list of predefined answers. *(Elby 2000, Hutchison & Hammer 2009)*
- ✓ Project-based classrooms help students to work together to take on realistic problems. *(Stevens 2000)*

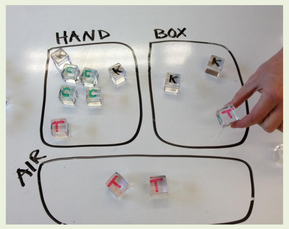
Energy Project K-12 Professional Development

Energy Theater

Rules:

- Each person (cube) is a 'chunk' of energy
- Objects in the scenario correspond to locations on the floor (white board)
- Energy forms are indicated with hand signs, movements, or letters
- As energy transfers and transforms among objects, people (cubes) move and change label.

Energy Cubes



Energy Theater emphasizes conservation of energy by requiring the total number of 'chunks' of energy to remain constant throughout the energy process.

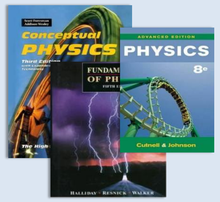
"In Energy Theater, the more useful the form of energy is, the taller you stand or something. And every time the energy becomes less useful, like if it's sound or heat or something like that, that they [the students] shrink."

Teachers want energy usefulness in the energy representation

Teachers discuss the benefits and limitations of Energy Theater and propose an additional representation for the usefulness of the energy forms. Here, a teacher suggests that students should shrink down as they become less useful energy.

Physics Perspective

Physicists want to teach:

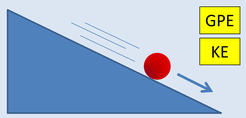


Conservation of energy

$E_{initial} = E_{final}$ (Closed system)

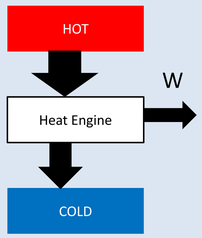
Forms of energy

Kinetic, Gravitational Potential, Thermal, etc.



Efficiency

$$\frac{Work_{out}}{Energy_{in}}$$



Entropy & 2nd Law of Thermodynamics

Toward A Coherent Energy Model that…

…is responsible to advanced physics.

…is accessible to elementary teachers.

…creates meaningful connections between energy that is conserved and energy that is used up.

Socio-political Perspective

Students want to learn:

Conserving energy

Saving, not wasting energy

Sources of energy

Wind, Nuclear, Solar, Geothermal, Coal, etc.

Efficiency

Cheaper, faster, longer lasting, more useful for humans

Spontaneous learner interest in "usefulness"

Energy's value has decreased.

The quality of the energy decreases as it dissipates.

Energy is used up and becomes less available.

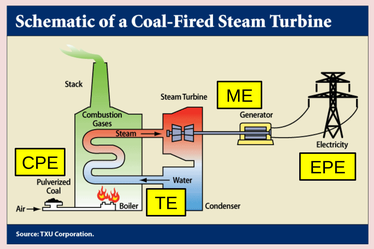
Energy degrades into a less useful form.

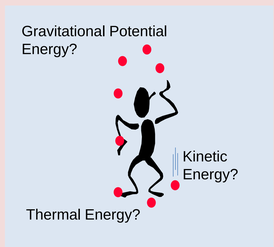
When is energy useful?

Also seen in:

- Duit (1984)
- Papadouris and Constantinou (2010)
- Pinto, Couso, & Gutierrez (2004)
- Solomon (1982, 1985, 1992)

What form of energy is most useful?





Seattle Pacific University
ENERGY PROJECT
PHYSICS EDUCATION RESEARCH AT SEATTLE PACIFIC UNIVERSITY
FACET INNOVATIONS
NSF
Supported in part by NSF grant DRL0822342