

Representing energy transfers and transformations

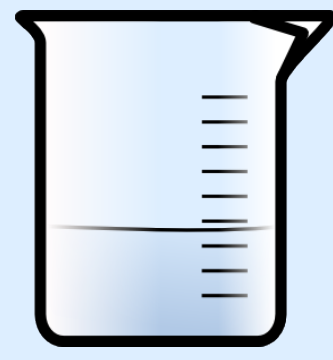
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Goals for energy learning

SUBSTANCE MODEL OF ENERGY

Energy is a kind of stuff (invisible, massless, etc.); objects are containers that can have such stuff in them.



ENERGY DYNAMICS

Detailed tracking of energy transfers and transformations in real-world processes



Features:

- (Observed in forms)
- Can transform
- Is located in objects
- Transfers among objects
- Is conserved

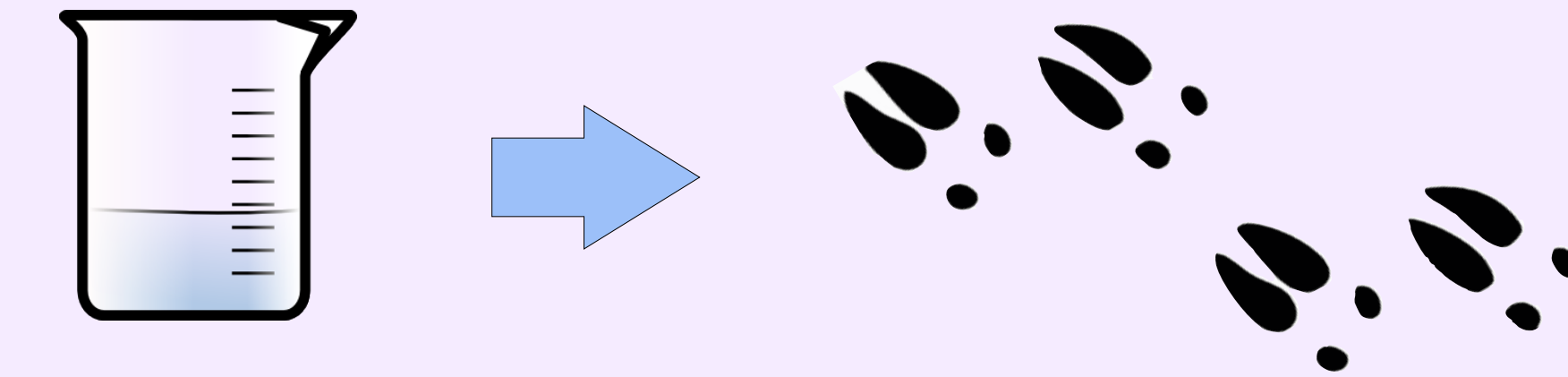
Theoretical perspective

- ◆ **Representations are culturally-produced artifacts** that speak with the voice of the culture that produced them.
- ◆ **Representations have cognitive agency.** They function as though they can talk, listen, remember, and ask questions.

Latour, 2005; Hutchins, 1995; Sison, 2006

Claim

Representations that articulate a **substance model of energy** foster **detailed tracking** of energy transfers and transformations in complex real-world processes.

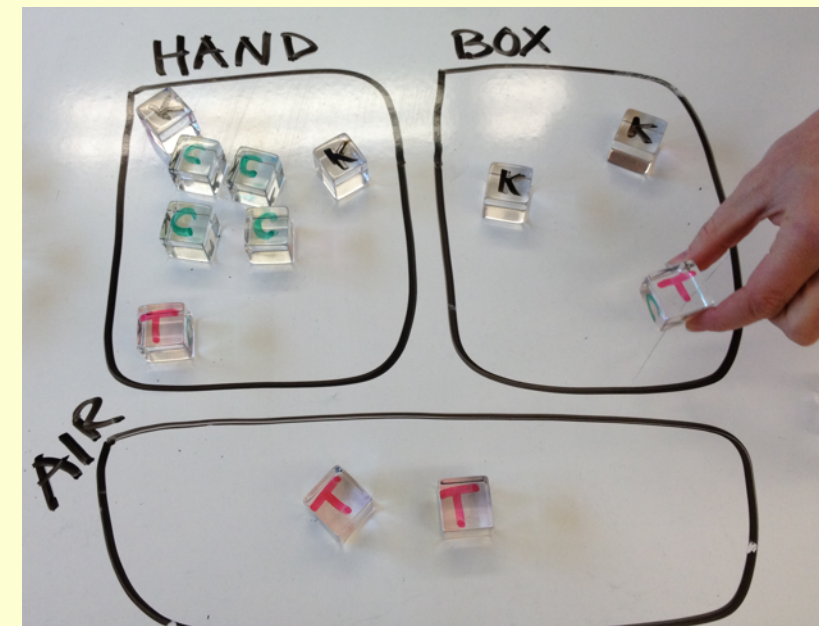


Energy representations



Energy Theater / Energy Cubes

People/cubes are units of energy. Objects in scenario are areas on the floor/whiteboard. Forms are indicated with hand signs or letters on cube-sides. As energy is transferred among objects, people move to different locations on the floor, or cubes move and flip.



Representation



What it "says"

"Energy is located in objects. Every unit of energy has a form. Energy moves among objects and transforms."

"There is a total amount of energy. That whole amount is divided into parts."

"There are different categories of energy."

"Energy goes from one object to another. Forms are labels for energy."

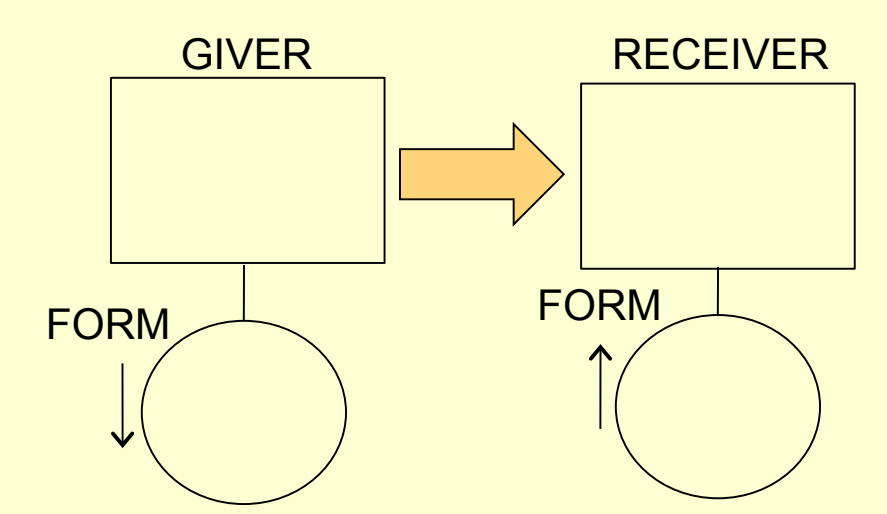
Questions it asks

"Where does the energy start? Where does it go after that? What form is each unit of energy in at each moment?"

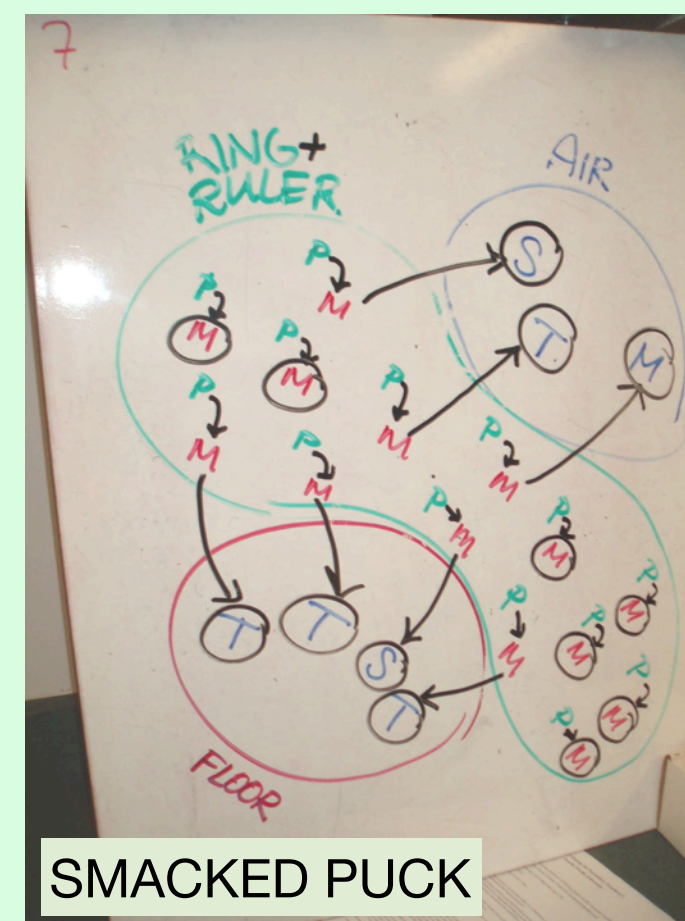
"What proportion of the energy is in each form?"

"Which form has the most energy in it?"

"What is the source and what is the destination of the energy? What form of energy goes down in the source, and what form goes up in the receiver?"



Learner-invented representations: Evidence of tracking energy transfers and transformations

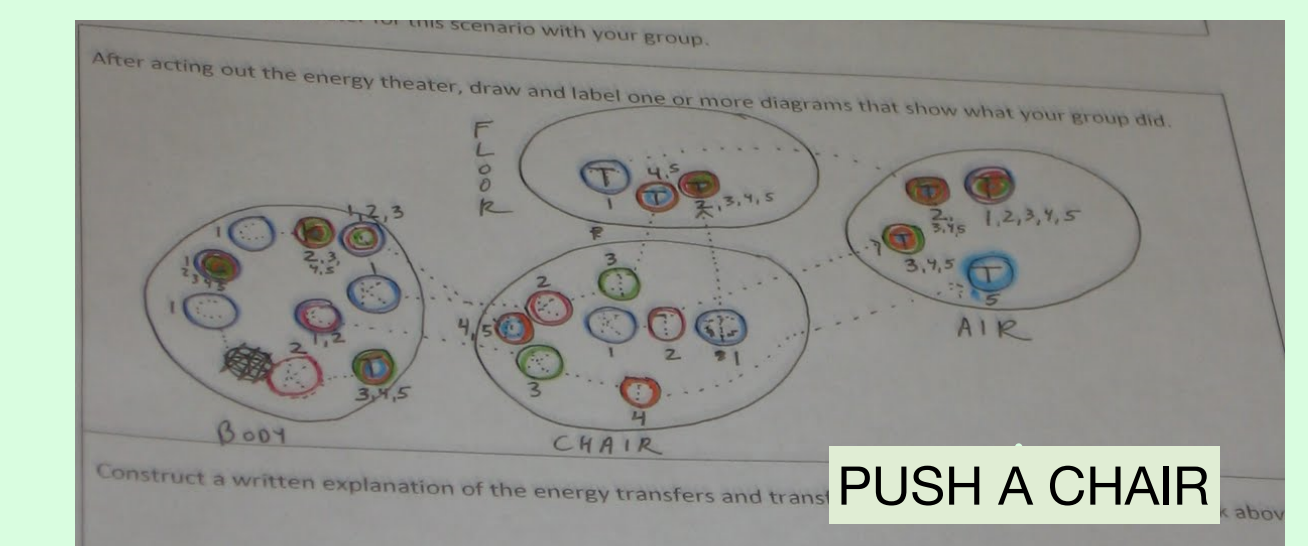
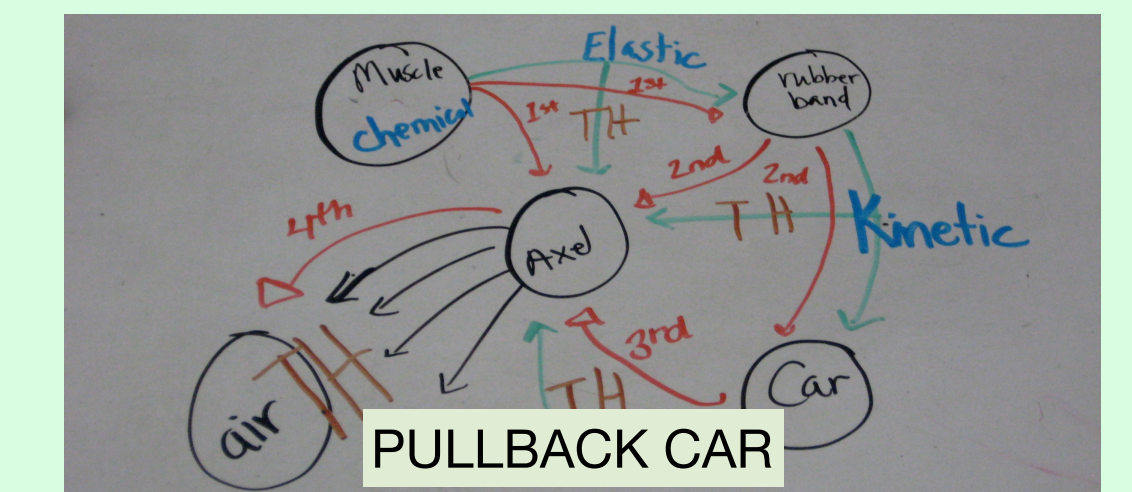
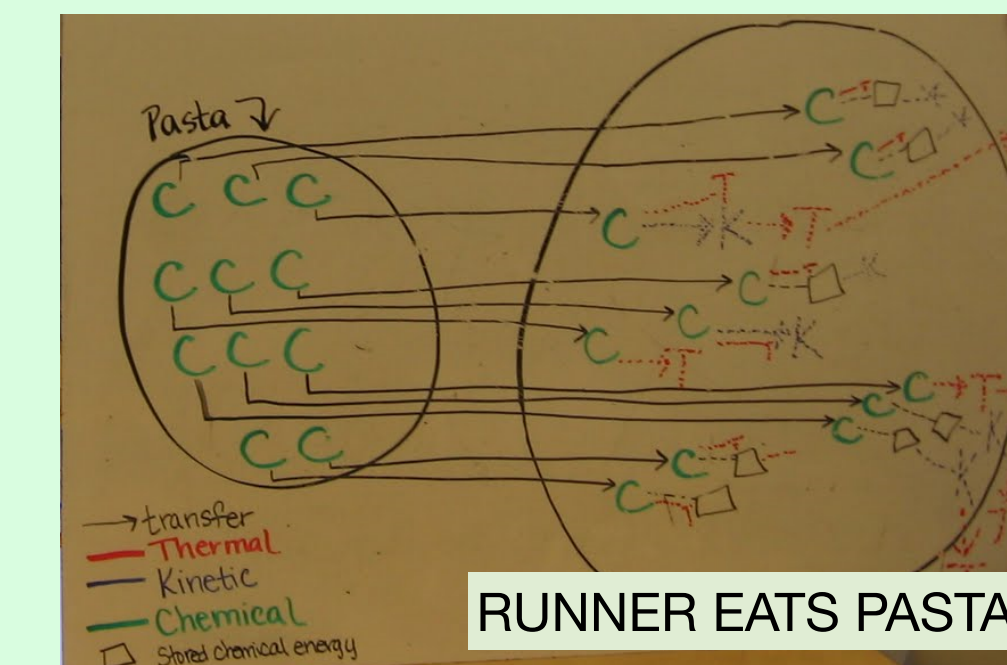
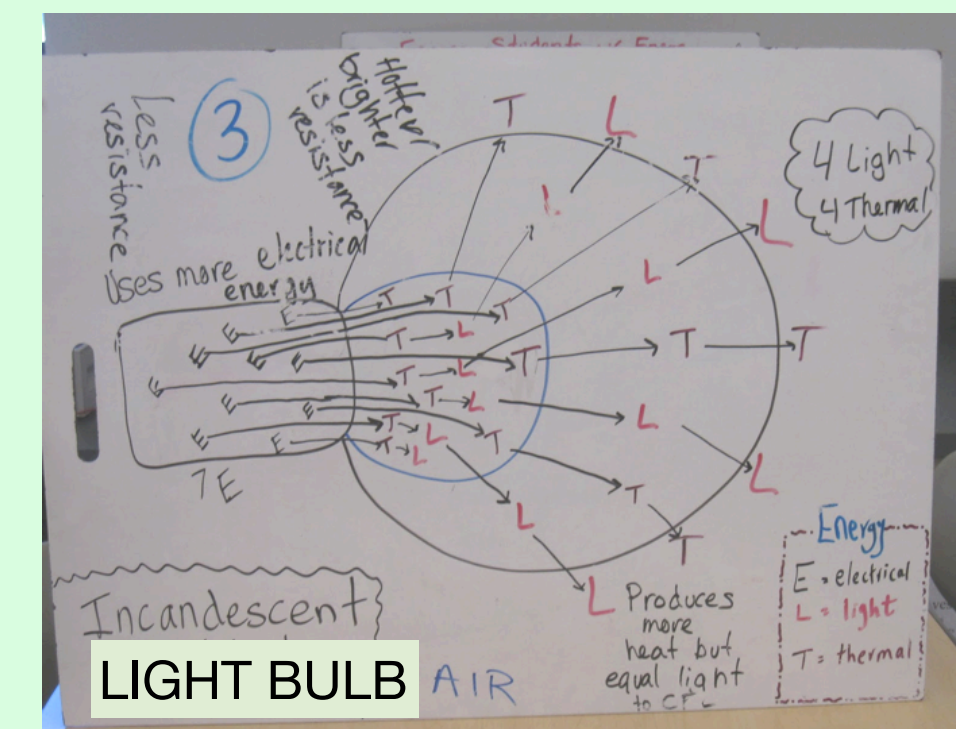
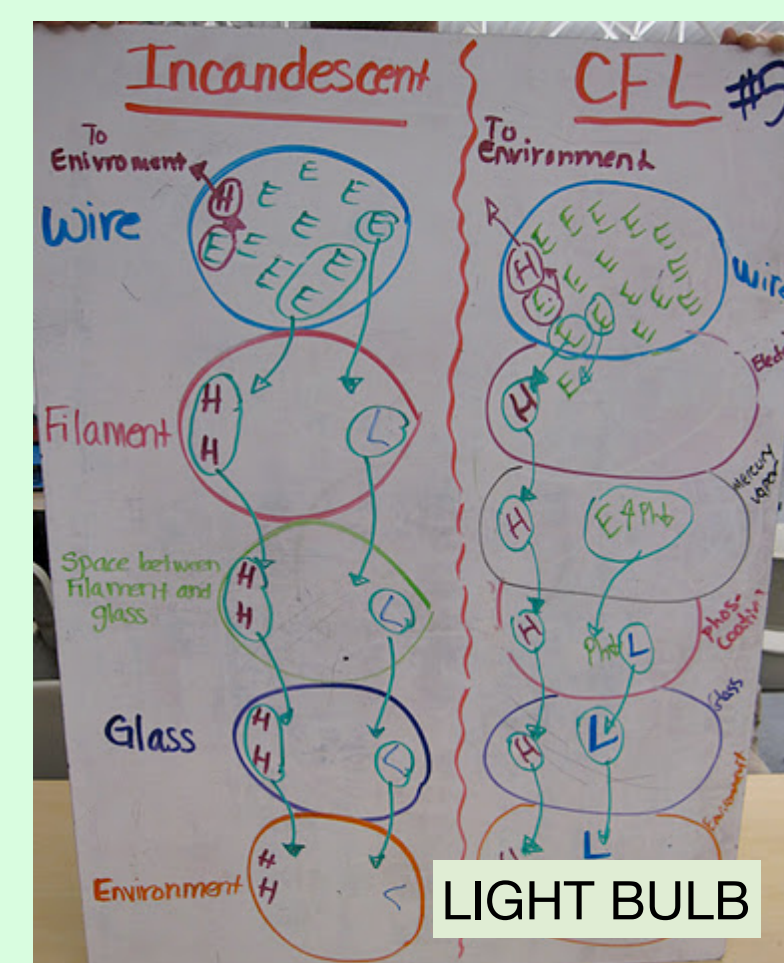
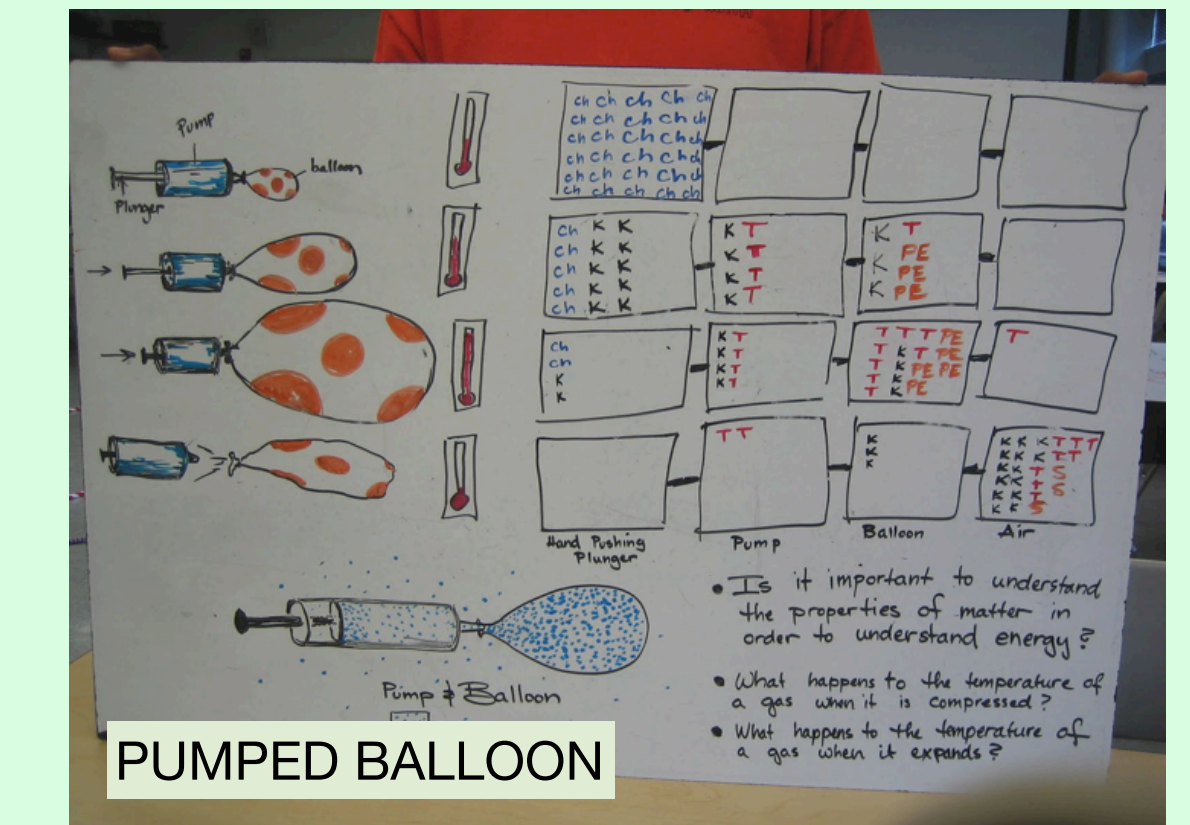


What?

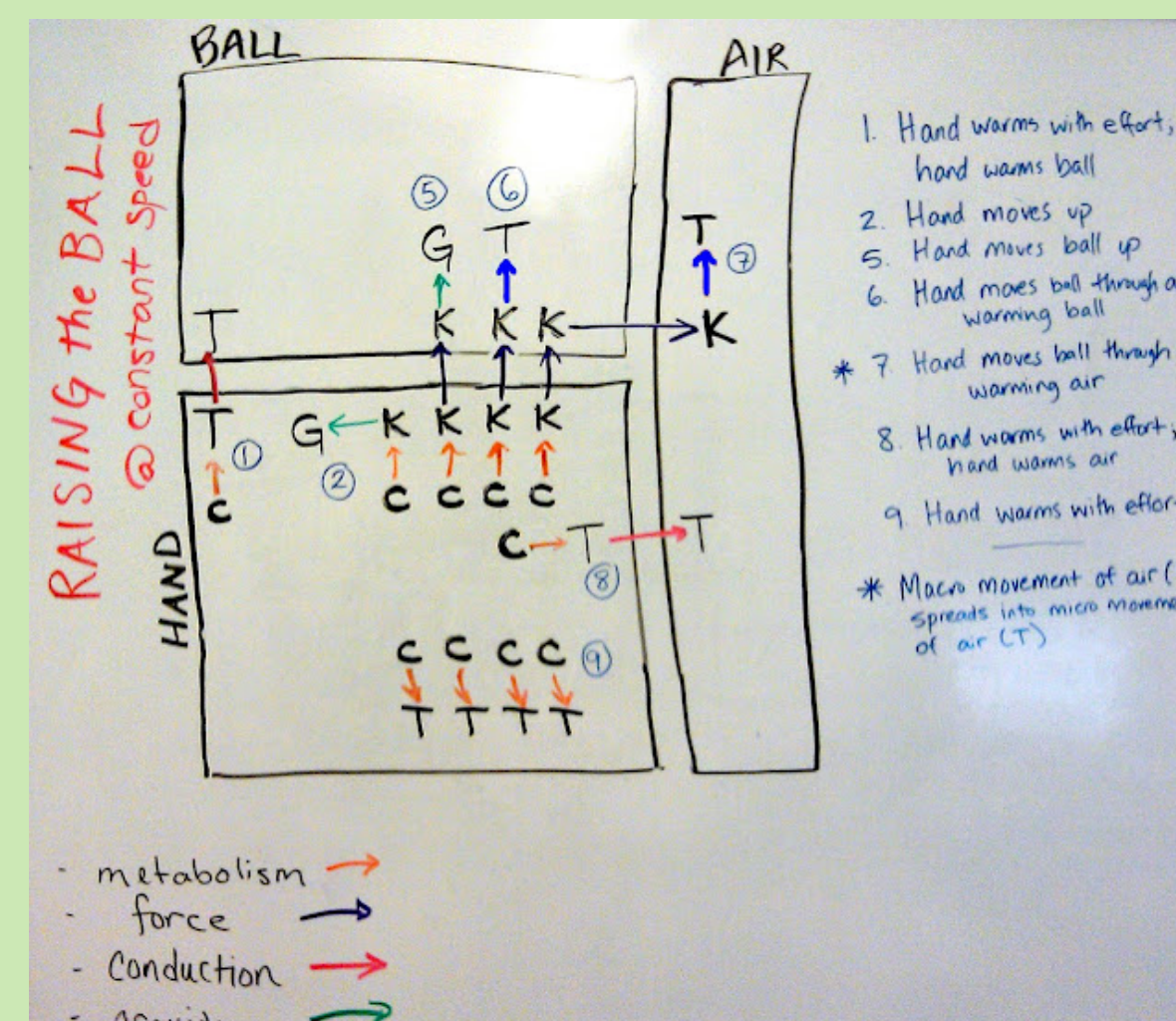
- Units of energy
- Objects
- Forms of energy
- Time evolution

How shown?

- Letters or dots
- Schematic areas or pictures
- Letters, colors, or both
- Arrows or diagram sequences

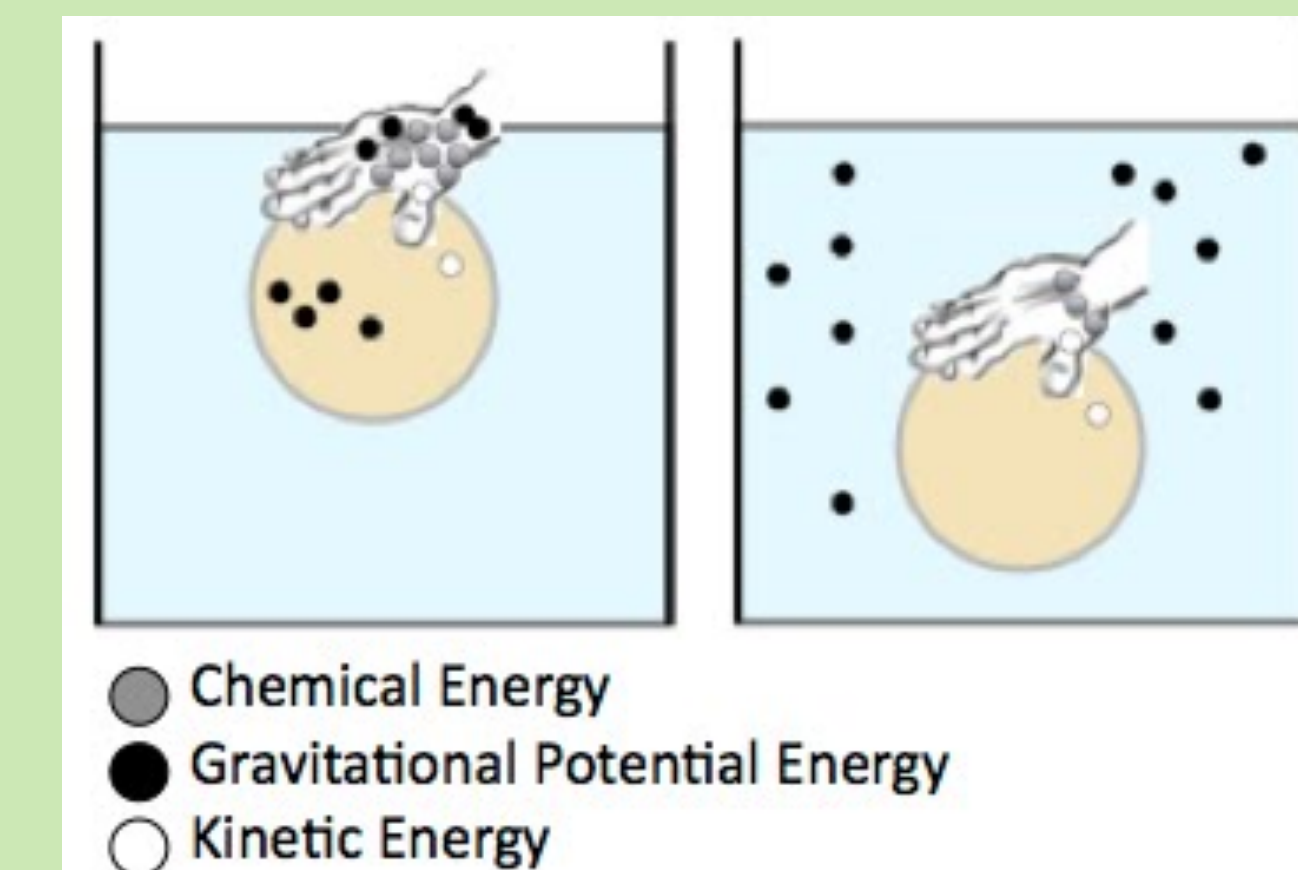


Expert-refined representations: for physics understanding, teaching, and video analysis



"Energy Theater Diagram"

- Objects are areas on whiteboard
- Units of energy (including forms) are letters
- Arrows are transfers or transformations of energy
 $K \rightarrow K$ is a transfer (in Energy Theater, moving person)
 $K \rightarrow T$ is a transformation (in ET, change of hand sign)
- Process by which transfer/transformation occurred indicated by arrow color



"Energy Movie"

- Objects are pictorial
- Units of energy are dots; forms are colors
- Transfers and transformations are shown dynamically