Educators explore innovative 'theater' as a way to learn physics

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In a study released last week, education researchers found that personifying energy allowed students to grapple with difficult ideas about how energy works. Contrasted with more traditional lectures and graphs, this innovative instructional technique may be useful for teaching about other ideas in physical science, which commonly deals with things that change form over time.

Energy is a very important concept across many fields of science, and is a key focus of the new national science standards. Energy is also a central player in several global issues, such as climate change and fuel economy. However, energy is a challenging concept to fully understand. While energy can be precisely defined mathematically, it is often difficult to grasp intuitively. Energy can change form – a ball held at some height has energy due to the pull of gravity, which gradually becomes energy of motion as the ball falls. However, no energy is lost in the process, a property called "conservation of energy." These basic ideas may seem straightforward, but when applied to real world situations (like fuel economy), they become very challenging to think about.

"Existing representations [such as bar charts] don't emphasize the thing that we care most about energy in physics, which is that it's conserved," said lead author Rachel Scherr, of Seattle Pacific University. These other instructional methods also don't show how energy moves among different objects in a system.

In the current study, the researchers report their ongoing examination of an activity that they have created, called "Energy Theater." Energy Theater is specifically designed to help learners visualize energy and how it dynamically changes form and location. In Energy Theater, learners (K-12 science teachers in this study) each play the role of one "chunk" of energy, and indicate with hand gestures what form that energy has (e.g., chemical, motion, gravitational, thermal). Different objects are represented by loops of rope on the ground, and learners can move from object to object, demonstrating energy moving between those objects. While energy is not actually a material substance, this metaphor can help learners think about how a fixed amount of energy can flow between different objects.

For example, the group may be given the problem of, "Show what happens when a hand pushes a box across a table." Participants would first stand in the area representing the hand, making the gesture for "chemical energy." One by one, they would move to the area representing the box, changing their gesture to "energy of motion." Other scenarios might include how energy flows when an incandescent light bulb is turned on. The group must work together to decide how the "theater" will play out for a particular situation, making complicated decisions about just where and when the energy will flow and take different forms.

"These elaborate stories about energy dynamics are not usually told," said co-author Hunter Close of Texas State University. "In order to tell [these stories], we have to act them out, because they are so complicated." The authors note that the specific attributes of Energy Theater help support this deeper learning: "I think the important message is that diverse learners can figure out all kinds of sophisticated energy scenarios once they have a representation for doing so," said Scherr. Energy Theater automatically keeps track of how much energy is located in different places, emphasizing conservation. It also serves as a visual "memory" for the group, helping them to keep track of the different moving parts. "It's also kind of fun and enticing," said Scherr. "It's an opportunity to interact. It's easy to feel very involved in what the group is doing."

Current evidence for the effectiveness of the activity is that learners are able to generate very detailed energy tracking diagrams after the activity. Analysis of the groups' conversations as they work to script out the "play" also demonstrates the complexity of the ideas that the group is working to understand.

The team suggests that Energy Theater is a useful addition to more traditional instruction, enriching the student's development of ideas about energy. This approach might also be fruitfully applied to other areas of science involving dynamic processes – for example, people might represent atoms in a substance, which can change state from solid to liquid to gas. The authors report that teachers typically appreciate the tactile nature of the activity, its appropriateness for English language learners, and the fact that all students have to participate.

Energy Theater also gives students an authentic, broad repertoire of problem-solving strategies. "Learning is done by people, not by brains in jars," said Close. Added Scherr, "In normal life, when we're trying to figure out something together, we do it using our words and tone of voice and gestures or body and we might act something out. Energy Theater legitimizes all those things and uses them to solve sophisticated problems."

More information: "Negotiating energy dynamics through embodied action in a materially structured environment," Rachel Scherr, Hunter Close, Eleanor Close, Virginia Flood, Sarah McKagan, Amy Robertson, Lane Seeley, Michael Wittman and Stamatis Vokos, Physical Review Special Topics – Physics Education Research, prstper.aps.org/abstract/PRSTPER/v9/i2/e020105

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