Boston Energy in Science Teaching

Boston Science Partnership: Phase II

The BEST Definition of Effective Teaching

Definition: Facilitating opportunities for learners to understand concepts and make connections across science disciplines. The BEST project's strategy is to use the cross-cutting concept of energy to facilitate these opportunities.

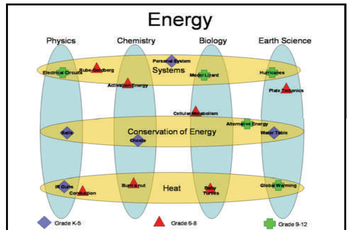

Fig 1: Illustration of how 3 of 4 Energy Themes in Energy I and Energy II pervade the four major science disciplines and grades K-12.

Project Assumptions
- Energy is a core concept to all sciences.
- Increasing teacher content knowledge is necessary for energy connections across disciplines to be made.
- Making connections across curriculum leads to more efficient and effective teaching, which can measured by student achievement and engagement in science.
- There are many learning styles. Focusing on core-concepts, like energy, may help some—but not all—students learn better.

Goals:
- To better understand how increasing teacher knowledge increases student achievement and research why our model is effective
- To increase teacher understanding of science and therefore teacher efficiency and effectiveness at teaching existing curricula
- To engage university faculty in a deep discussion cross-disciplinary science education in order to spark new research directions and changes in STEM education
- To increase student interest and achievement in science in grades 3-8.

Encouraging Effective Teaching through Energy

"I am aware now, but I need to practice and plan more lessons. It will take a little time."—Energy I Teacher, Interview

- **Content Knowledge**: Content knowledge gains were self-reported by participants in all strategies. Content knowledge is not just gained through formal intrusion in graduate courses.

- **Making Connections:** All of our PD strategies have increased teachers' understanding of energy connections throughout the curriculum. This should lead to connections then being made for students.

- **Practice:** Teachers need practice at incorporating new content/concept knowledge into lessons. For practice occur, they need opportunity and support.

- **Multiple Approaches**: Multiple approaches are needed to bring teachers along and meet project goals. VP is best at having teachers use energy as a lens in instruction; Energy I (UMB) is best at transferring concepts between disciplines; and Energy II is best at having teachers own the work.

Please rate on a scale of 1 (low/never) to 5 (high/frequency)	**Pre E1 UMB (n=14)**	**Post E1 UMB (n=17)**	**Pre E1 NEU (n=32)**	**Post E1 NEU (n=31)**		**Pre E2 Course (n=4)**	**Post E2 Course (n=4)**	**Pre EVPI (n=13)**	**Post EVPI (n=10)**
a. Your **understanding** of how energy connects across the instructional materials you teach	2.9	3.8	3	3.7		3.5	4.3	3.2	4.3
b. Your **level of interest** in the "big ideas" of science	4.5	4.6	4.3	4.5		4.5	5	4.8	4.8
c. Your **ability** to **transfer knowledge** from one discipline to another (e.g. physics to biology)	3.2	4.2	3.7	3.6		4	4	3.9	4.1
d. Your **level of understanding** of the content of the curriculum that you are currently teaching	4	4.4	3.9	4.1		4	4.8	4.5	4.5
e. Your **level of confidence** in your science teaching overall	3.6	3.9	3.6	3.9		4	4.5	4.2	4.3
f. Your current **level of content knowledge** of energy concepts	3.4	3.7	3	3.5		3.5	4.3	3.8	4.1
g. How often you use **energy as a lens** in your science teaching	2.3	2.9	3.1	2.8		3.5	4	**2.8**	**3.7**
h. How often do you organize your teaching around the "big ideas" of science in your classroom teaching	3.2	3.6	3.4	3.6		3.4	4.3	3.7	4.1

Figure 3: Year 1 external evaluation findings from Program Evaluation and Research Group, Lesley University.

- **University Effectiveness:** Energy I was taught for first time at NEU. Evaluation impacts are lower than the UMB course (taught four times) but we anticipate they will go up with each successive iteration.

BEST Professional Development Strategies: Application to Effective Teaching

Energy I Graduate Course	Energy II Graduate Course	Energy Vertical Teaming	Energy CCLS	University Energy Series
Increase Content Knowledge: • Learn key concepts of energy transformations, law of conservation, energy in systems, and energy resources. • More content knowledge provides a better understanding of curriculum. • For energy, content-knowledge in and outside of a teacher's "home" discipline is necessary to make connections. **Exposure to Connections:** • Increasing energy content knowledge and exposure to science concepts provides a more connected view of science. • Energy content is explored through examples in biology, chemistry, physics, and earth science.	**Deepening Content Knowledge:** • Course goes deeper into the four energy concepts that are taught in Energy I. • Professors participate in CCLS as a content expert to help identify missed opportunities in lessons. **Practice and Feedback:** • Teachers get practice on incorporating energy into their lessons during the class. • Participants videotape themselves three times during the course. Also allows for self-reflection to occur, which can lead to changes in practice. • Speed-dating is used as a tool to give and receive quick feedback on lesson plans and its incorporation of energy. • More detailed feedback is given through CCLS protocol during class.	**Identification:** • Identify energy concepts in each FOSS kit and high school curriculum. • Lay out connections in K-12 grid. **Mapping:** • Color code energy concepts by theme to illustrate where energy connections exist throughout curriculum. • Energy concepts are so pervasive that there is not a straightforward vertical or horizontal alignment to them.	**Research:** • Teachers select a research article to gather information about how to teach energy or about energy concepts to inform their practice. **Observations:** • Teachers—as a group—taking turns observing each other. • Observations help to contextualize the research in practice. • Observations break down the isolation of instruction. **Feedback:** • After each observation, a debrief takes place to give warm and cool feedback. • Research article is applied to what is discussed in the debrief. • Student work is looked at to show evidence of understanding of concepts.	**Research:** • Teachers select a research article to gather information about how to teach energy or about energy concepts to inform their practice. **Observations:** • Teachers—as a group—taking turns observing each other. • Observations help to contextualize the research in practice. • Observations break down the isolation of instruction. **Feedback:** • After each observation, a debrief takes place to give warm and cool feedback. • Research article is applied to what is discussed in the debrief. • Student work is looked at to show evidence of understanding of concepts.

Challenges and Lessons Learned

Energy is Difficult	• Energy is so pervasive that it is challenging to fully map out and connect in the curriculum. • Need faculty members from different departments to teach Energy I and Energy II. • Need to be more strategic in the way we go about documenting energy. We cannot do everything at the same time.
Thinking Outside the Silos	• Others are thinking about energy but more about energy content within disciplines. We are thinking about it across disciplines. • Because we are thinking about it differently, we have to be better at communicating what we mean and why we think this is worth exploring.
Change is Discrete	• Teacher observations are great for documenting change but only if you see that change during the observation. • Observable change may not happen during the life of the project. • Change can be occurring but not observable (happens in non-observed lessons, is changing how a teacher thinks but not what they are doing in the classroom, etc.).
Lack of Existing Assessments	• Currently, students are not specifically tested in energy, like we do biology or physics. • Most assessments, both for teachers and students, focus on energy in physical science or in ecosystems but not connections between the two. • Assessments as a whole can be interdisciplinary but individual questions are hard to write, especially in a multiple choice format.
Recruitment	• The above four reasons have led to difficulties in recruiting participants. • Lack of incentive for teachers to register for energy PD because it is not obvious how it will be helpful. • Recruitment challenges impact research. • Energy is powerful and valuable to teachers once they take the PD. Challenge is communicating to this prior to PD.

Citations and Informational Readings

Boston Science Partnership Website-www.bostonscience.org

Doménech, J., D. Gil-Pérez, et al. (2007). "Teaching of Energy Issues: A Debate Proposal for a Global Reorientation." *Science & Education* **16**(1): 43-64.

National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press, 2011.

Nordine, J., Krajcik, J. and Fortus, D. (2011). Transforming energy instruction in middle school to support integrated understanding and future learning. *Science Education*, 95: 670-699.

Osterman, K.F. and Kottkamp, R.B. (1993). *Reflective practice for educators: Improving Schooling through Professional Development* . Newbury Park, CA: Corwin Press.

Authors: Bob Chen, Jennifer Dorsen, Arthur Eisenkraft, Joan Karp, Tala Khudairi, Abigail Levy, Pam Pelletier, Allison Scheff, and Christos Zahopoulos. For more information, please contact Allison Scheff, Project Director, at allison.scheff@umb.edu.

NSF DUE-0928666