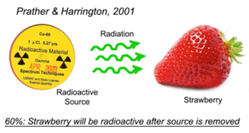
Nonscience Majors' Thinking About Ionizing Radiation

Andy Johnson and Anna Hafele Black Hills State University

andy.johnson@bhsu.edu www.camse.org/radiation



Researchers have uncovered difficulties with distinguishing radiation from radioactivity (Eijkelhof, 1990; Millar & Gill, 1996; Prather 2005). All found student failure to distinguish between irradiation and contamination, or between the radioactive source and radiation emanating from the source.

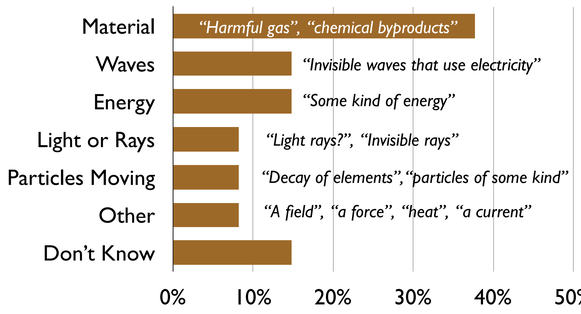
Understanding radiation requires "concept differentiation", a form of conceptual change (Dykstra, 1992).

If students must change their thinking about radiation, what are they thinking in the first place?

The Radiation by Inquiry Project (DUE 0942699) is developing inquiry based course materials for non-science majors to understand ionizing radiation. We find significant native views of radiation that problematize students efforts to develop useful models of radiation.

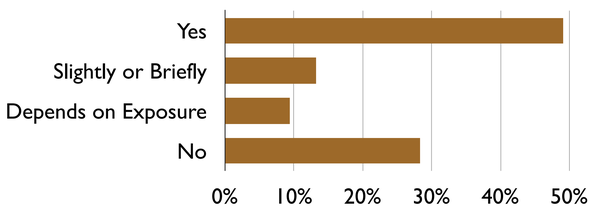
At the beginning of the unit, students answered questions eliciting their initial ideas about radiation. Three sections of non-science majors offered the following answers:

What is Radiation? (N=63)

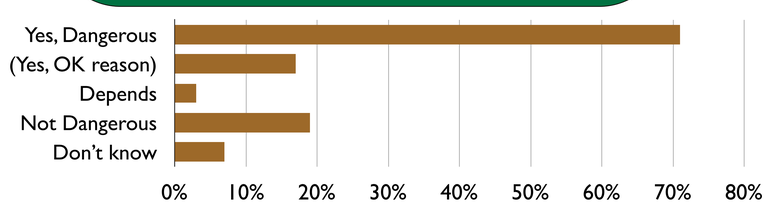


Radiation - a process of particle emission - is in a **different ontological category** from "harmful material". According to Carey (1988) changes in ontological commitments require "strong restructuring" or significant conceptual change.

If someone got radiation poisoning, would they be radioactive? (N=53)



Is it dangerous to get near a sealed drum of radioactive waste? (N=60)

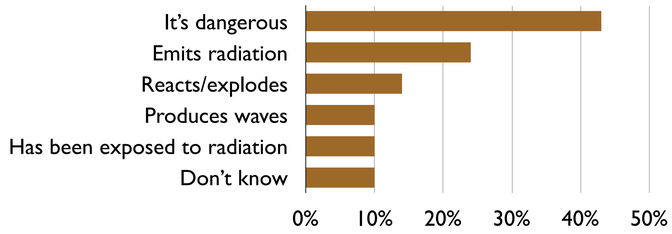


You don't have to touch it to become radioactive, the fumes and gases affect you. . .

Radiation puts off waves so it's hard to store.

You're safe because the field stays within the drum.

If we say something is radioactive, what might that mean? (N=21)



Undifferentiated Radiation Concept (Eijkelhof, 1990):

Radiation/radioactivity is a kind of substance that is emitted from radioactive objects, absorbed by other objects, and can be reemitted. It is dangerous/toxic/bad.

Student interpretations of radiation:

1. We find the same undifferentiated radiation concept as Eijkelhof
2. Students mention waves or energy, but are not thinking of these as physicists would.
3. Not distinguishing from chemical ideas

Some ideas held with strong commitment

Why "Waves" of radiation?

1. *Micro-* ***Wave*** *oven makes hazardous radiation.*
2. *"It's called Radio Activity. There are radio waves, so radioactivity obviously is wave activity!"*

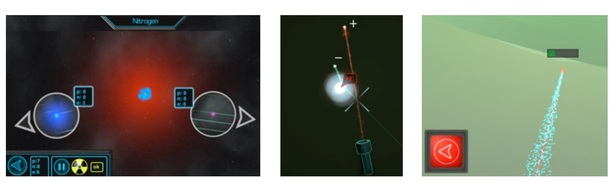
Strategies for promoting changes

1. Contrast chunks vs. continuous immediately.
(Is the detector detecting something continuous like water or chunks like ice cubes falling from a pitcher?)

2. Test contamination belief directly - tape sources to victims and check for radiation days later.

3. Hunt for sources of radiation using EM detectors as well as geiger counters

4. Extensive investigations of phenomena **repeatedly link macroscopic scale to atomic & cellular scale.**

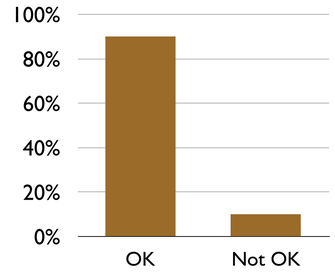


"Compare" . . .
"Explain" . . .
"Why"?

(Yet to try: Millar & Eijkelhof's "**source-radiation-detector**" model.)

Learning Results (N=21)

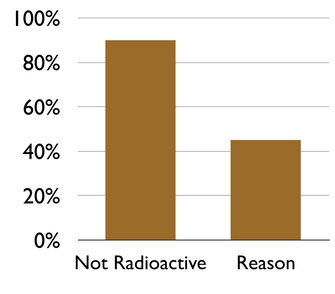
Radiation comes from nuclei



Data from end of unit, Spring 2011.

Students recognize radiation comes from nuclei and talk readily about radiation as particles traveling from nuclei that have excess neutrons.

Will spinach become radioactive?

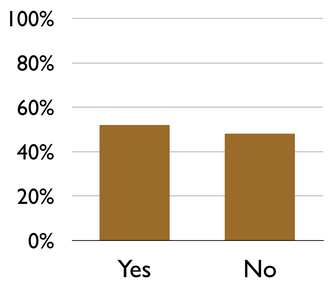


Spinach question:

"If we leave radioactive discs on a spinach plant, will it become radioactive?"

Students correctly answer "no" but many explain that the sources are not strong enough, or that the particles don't stop in the plants!

Is an alpha radioactive?

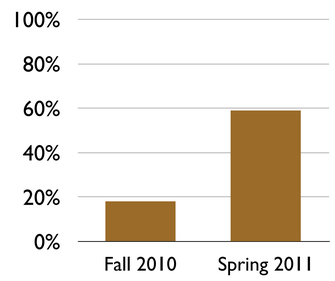


Alpha emission question:

Only half of the class has distinguished "radioactive" from "radiation particle".

Students may have assigned "dangerous" to radiation particles, which could trigger "radioactive".

Why is it called ionizing radiation?



Ionizing question:

To answer correctly based on reasoning, students must envision radiation particles traveling through atoms and removing electrons.

Previous semesters had success rates under 20%. This level of success is a breakthrough!

References:

Carey, Susan (1988). Reorganization of Knowledge in the Course of Acquisition. Ontogeny, Phylogeny, and Historical Development. S. Strauss: 1 - 27.

Dykstra, D. (1992). Studying conceptual change: Constructing new understandings. Research in Physics Learning: Theoretical Issues and Empirical Studies Proceedings of an International Workshop at University of Bremen. R. Duit, F. Goldberg and H. Niedderer. Kiel, Germany, IPN: 40-58.

Eijkelhof, H. M. C. (1990). Radiation and Risk in Physics Education. Utrecht, University of Utrecht. http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/22/010/22010294.pd

Millar, R. and J. S. Gill (1996). "School students' understanding of processes involving radioactive substances and ionizing radiation." Physics Education 31(1): 27 - 33.

Prather, E. (2005). "Students' Beliefs About the Role of Atoms in Radioactive Decay and Half-life." Journal of Geoscience Education 53(4): 345-354.