Motivation
The Next Generation Science Standards (NGSS) call for a shift from science learning as a fixed body of decontextualized facts toward a deliberate integration of three dimensions that trans-cend instructional level: 1) Disciplinary Core Ideas, 2) Crosscutting Concepts, and 3) Science & Engineering Practices. This instructional model explicitly integrates the three dimensions of the NGSS as an organizing framework in undergraduate teacher preparation courses. We use ranking tasks to examine and assess student learning of Crosscutting Concepts in this integrated context.

Study Population & Course Context
California State University, Fresno:
- Designated as a Hispanic-Serving Institution and an Asian American and Native American-Pacific Islander Institution.
- Over 60% first generation college students.

Introductory Undergraduate Geoscience Courses Required for Liberal Studies Major, Enrollment ~50:
- Lower division GE:
  - Physical Science: think-pair-share w/ neighbor 2 lecture hours + 2 lab hour meetings per week
  - Upper division GE, integrated Physical & Life Sciences, explicit small-group work (POGIL);
  - 3 lecture hour meetings per week.

Conceptual Shifts in Science Instruction: Explicit Connections between Content, Practices, and Ideas

Content: Intro. to Earth Science
- Interconnected nature of science
  - Earth Systems, Plate Tectonics
  - Geologic Time & Dating, Atmosphere, Weather, and Climate
  - Natural Resources: Human Impacts on Earth Systems

Written Reflection
- PROMPT: (1) Select three crosscutting concepts and describe a specific example that illustrates that concept from course discussions or readings. (2) Select three scientific practices and describe a specific example of something that YOU did that illustrates you engaged in that practice in lecture class, lab, or reading.

Science & Engineering Practices
- Students engage with authentic exercises in physics, water, energy, and food resources.

In-Class Low Stakes Assessment

Instructional Prompts during i-clicker participation (El Prathur, pers. comm.):
1. Read question silently and respond (orally or in writing)
2. Turn to your partner and convince them you know the correct answer.
3. Even if you have the same answer, you have to be able to explain your choice

Open-Ended Prompt
What crosscutting concept could be... must useful for your learners in understanding this example? most relevant to this discussion? important for understanding this topic?

Examination: Short Answer

Methods & Instrument
We constructed a series of Ranking Task Exercises (O’Kuma, T.L., Maloney, D.P., & Heggele, C. J. (Eds.). (2000). Ranking task exercises in physics (Vol. 26). Upper Saddle River, NJ: Prentice Hall), in which students were presented with a real-world phenomenon, and asked to select which Crosscutting Concept is MOST USEFUL in understanding the phenomenon. They also are asked for a justification for their ranking.

Crosscutting Concept Rankings Tasks

Conclusions
- Common themes included phases of matter, feedback, ecosystem changes
- Some responses were outside of science, which may reflect a lack of content
- Different concepts of “environmentality” among the responses: e.g. feeling safe or stable, or feeling like it gives others an advantage...and they might change their answer and agree on something together.

Naive Explanations
- “Stability and change due to the mobility of the core and the change she needs to go.”
- “I think energy and matter would be the most useful crosscutting concept because for an ice skater to stay traveling at a fast pace, they need to gain energy to increase their speed.”

Implementation & Future Work
- “Explicit use of NGSS as a curriculum framework promotes deeper understanding of disciplinary content – interconnected nature of science and real-world practice – Higher level cognition: content, practices, crosscutting concepts
- Explicit integration of “systems thinking” instruction may be most useful for developing an understanding of CCCs #3-7.
- The ranking task exercises may be useful for identifying common misconceptions. Responders must explain their choice often reveal their level of understanding of different concepts.
- Need to examine understanding after multiple courses in other disciplines.
- Development of disciplinary literacy requires explicit use of language from the CCCs.

Funding & Support
- Help us pilot the ranking task: http://geo.ge/f1Wnpl.
- Provide feedback to freneal@csufresno.edu

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Funding & Support

Connecting Science Learning for Future Teachers: Applying and Assessing the Three Dimensions of the Next Generation Science Standards in Teacher Preparation Courses

Fred Nelson, California State University, Fresno, Curriculum & Instruction, freneal@csufresno.edu
Mara Brady, California State University, Fresno, Environmental Sciences, mebrady@csufresno.edu

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