A Learning Progression-based System for Promoting Understanding of Carbon-transforming Processes (Carbon: Transformations in Matter and Energy)

Charles W. Anderson (Michigan State University); Daniel J. Gallagher (Seattle Public Schools); Kathleen Schwille (National Geographic Society); Karen Draney (Berkeley Evaluation and Assessment Research Center)

Summary
We have developed and validated a suite of tools based on a learning progression for understanding key carbon-transforming processes in socio-ecological systems at multiple scales, including cellular and organismal metabolism, ecosystem energetics and carbon cycling, carbon sequestration, and combustion of fossil fuels. These processes generate, transform, and oxidize organic carbon. The primary cause of global climate change is the worldwide imbalance among these processes.

Suite of tools
1. Learning progression framework
2. Tools for principle-based reasoning
3. Teaching strategies for responsive teaching
4. Formative and summative assessment tools
5. Teaching materials and activities
6. Professional development materials

Research goals
1. Validate the learning progression framework
2. Identify sequences & mechanisms of learning
3. Determine effectiveness of teaching tools, strategies, and materials
4. Relate teacher knowledge, beliefs, classroom practice, and student outcomes to teacher support and professional development

Participant locations
Seattle, WA
Bellevue &
Station, MI
Fort Collins, CO
Santa Barbara, CA
Kansas City, MO

Learning progression framework
Level 2 Reasoning about the Carbon Cycle
Emphasis on actors and enabling conditions; confabulation of energy and matter
Level 4 Reasoning about the Carbon Cycle
Systems moving matter and energy, constrained by conservation principles

Formative and summative assessment tools
- Online and paper assessments, with interpretation guides linked to learning progression levels
- Student interview protocols

Teaching materials
Carbon Transformations in Matter and Energy (Carbon TIME)

Teaching strategies
Student responses to interviews and written assessments, with learning progression-based interpretation guides

Professional development materials
- Online and face-to-face professional development
- Formative and summative assessment tools
- Tools for reasoning and assessment outcomes
- Teaching strategies for inquiry and application

Selected Results
Percentages of responses coded as Level 4 explanations of carbon-transforming processes. Blue bars are end-of-course percentages in courses not using Carbon TIME materials. Red bars are from middle school teachers using Carbon TIME: baseline (spring of the year before using Carbon TIME), pretest (fall), and posttest (spring).

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