

Cyber-Enabled Earth Exploration (CE3): Development of Materials for Middle School Earth Science Instruction

The University of Montana

Primary Goal:

Create new inquiry-based, cyber-enabled instructional materials for teaching middle-school students that will increase students':

- > interest and engagement in earth systems science
- > content knowledge in earth systems science
- > technical skill using Google Earth and other Web 2.0 tools
- > geographic awareness, math competency, and writing skills
- > higher order thinking skills
- > self-efficacy in science and technology
- > understanding of the role of science and technology in society

Description:

The intent of the CE3 spiral curriculum is to help students learn about plate tectonics in an active manner, as a scientist would. Using their own observations, measurements, calculations, and scientific reasoning abilities, students embark on a Google Earth discovery that culminates in an understanding of the underlying causal mechanisms of volcanoes, earthquakes, and plate tectonics. In contrast to most curricula addressing this content area, we begin with volcanoes and end with plate tectonics. This is a deliberate attempt to help students experience the process of discovery that the scientific and lay communities have undertaken through the ages. That is, people's first understandings of natural phenomena are based upon what they observe and experience at the Earth's surface. These experiences foster curiosity about the essential nature of these events - how and why these things are happening. Over time, through concerted and cumulative observations, advances in technology, and new ways of thinking, we begin to build an understanding of processes occurring beyond our immediate experience. Used in the context of CE3, this progression is also meant to instill in students a sense of science being an ongoing, dynamic pursuit.

The CE3 curriculum consists of three modules with three investigations. At the end of each investigation, student understanding is assessed by a "Challenge Activity".

Introduction to Volcanoes	Introduction to Earthquakes	Introduction to Plate Tectonics
Volcanic Hazards & Benefits	Earthquake Hazards	Continental Drift
How Volcanoes Work	Geologic Faults	Sea Floor Spreading
Predicting Eruptions	Seismic Waves	Tectonic Plates

The CE3 Modules & Investigations.

The materials include Google Earth-based activities, student "field notebooks", a teacher's guide, challenge activities, and grading rubrics. They are all available to teachers and students at www.spatialsci.com/ce3. The website also provides a teachers' toolbox, including video tutorials, chat and discussion forum, and research data collection tools.

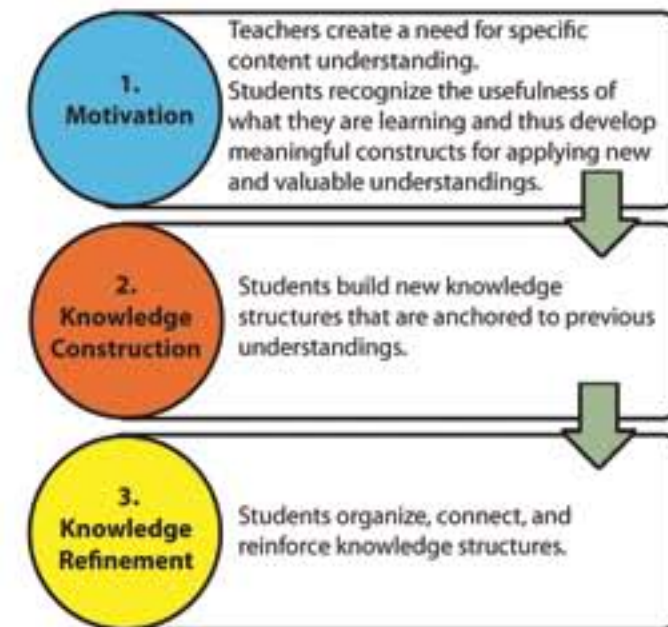


The CE3 project website.

Key Elements of the Design:

Learning-for-Use Design Framework:

A Learning-for-Use Design Framework (Edelson 2001) was used to promote engagement and motivation, and foster the development of useful science understandings that students can successfully access and apply in new contexts. The framework includes three steps which work at multiple levels within the curriculum.

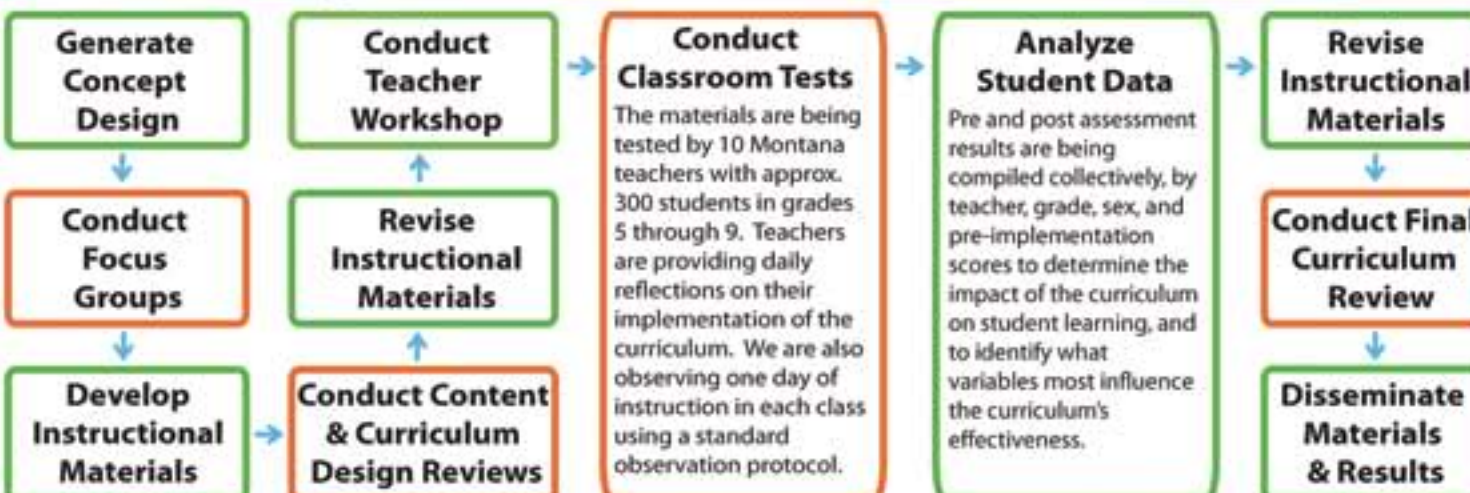


The Learning-for-Use Design Framework.

Metacognitive Reflection:

Each investigation begins with "Talking Points" to explore preconceptions and a classroom "story board" that is used to record "our best thinking so far". At the end of each investigation, a summary discussion is used to help students reflect on what they've learned. They then update their storyboard to record their collective learning.

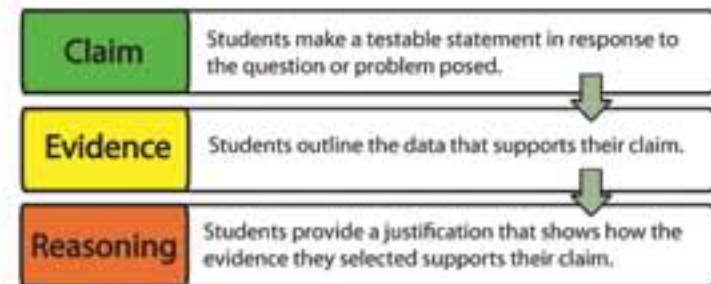
Research Activity Flow Chart:



Green blocks = CE3 team activities; orange blocks = external input.

Claims, Evidence, & Reasoning:

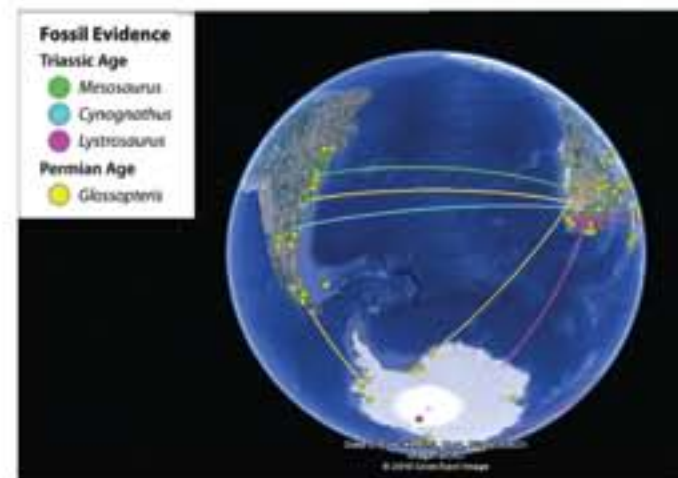
The curriculum includes the structured use of student field notebooks to record observations, make calculations, and construct scientific arguments using claims, evidence, and reasoning (CER; McNeill and Martin, 2010).



The CER strategy.

Google Earth:

Google Earth is used to convey content information through embedded multimedia, including text, images, video, animations, and GigaPans (high-definition, geo-referenced photographs), and as a geospatial visualization tool, allowing students to locate geographic features, make observations and measurements of those features, and create their own representations to aid in data analysis.



Fossil connections drawn by students to help visualize paleogeography.

Preliminary Findings:

Each classroom implementation was preceded by data collection, including an assessment of student content knowledge, scientific reasoning ability, and "science identity".

Pre-Implementation Scores:

- 0 The mean score was about 30% correct.
- 0 Performance generally increased from 5th to 9th grade (Fig.1).
- 0 Performance increased with increasing science identity (Fig.2).
- 0 Student's reasoning abilities increased with grade level (Fig.3).
- 0 Most students had difficulty discussing evidence and describing their reasoning (Fig.3).

Figure 1

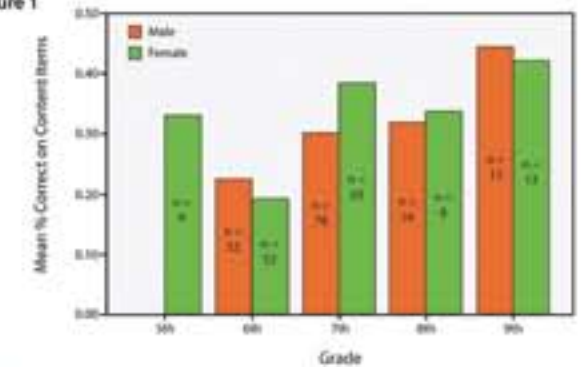


Figure 2

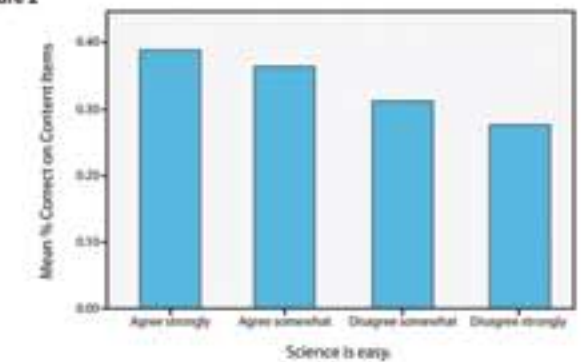
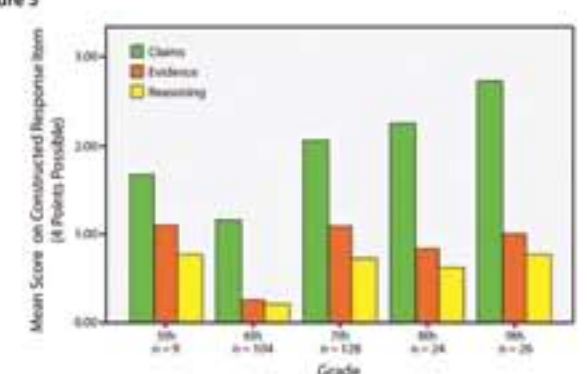


Figure 3



Teachers have been very positive about the materials and have identified two important needs:

- 0 Increased scaffolding of science concepts across grade bands.
- 0 Increased scaffolding of scientific reasoning.

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