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Assessing Climate Misconceptions of Middle School Learners and Teachers

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Abstract

Middle School students and their teachers are among the many populations in the U.S. with misconceptions regarding the science or even reality of climate change. Teaching climate change science in schools is of paramount importance since all school-age children will eventually assume responsibility for the management and policy-making decisions of our planet. The recently published *Framework for K-12 Science Education* (National Research Council, 2012) emphasizes the importance of students understanding global climate change and its impacts on society.

To address the lack of a well-designed middle school science climate change curriculum that can be used to help teachers promote the teaching and learning of important climate change concepts, we developed a 20-day Environmental Literacy and Inquiry (ELI): Climate Change curriculum in partnership with the Bethlehem Area School District, PA. Comprehension increased significantly from pre- to post-test after enactment of the ELI curriculum in the classrooms. This work is part of an ongoing systemic curriculum reform initiative to promote (1) environmental literacy and inquiry and (2) foster the development of geospatial thinking and reasoning using geospatial technologies as an essential component of the middle school science curriculum. The curriculum is designed to align instructional materials and assessments with learning goals. The following frameworks were used to provide guidelines for the climate change science content in addition to the science inquiry upon which schools must focus: *Climate Literacy: The Essential Principles of Climate Sciences* (U.S. Global Change Research Program, 2009) and the *AAAS Project 2061 Communicating and Learning About Global Climate Change* (AAAS, 2007). The curriculum is a coherent sequence of learning activities that include climate change investigations with Google Earth, Web-based interactivities that include an online carbon emissions calculator and a Web-based geologic time-line, and inquiry-based ("hands-on") laboratories. The climate change science topics include the atmosphere, Earth system energy balance, weather, greenhouse gases, paleoclimatology, and "humans and climate".

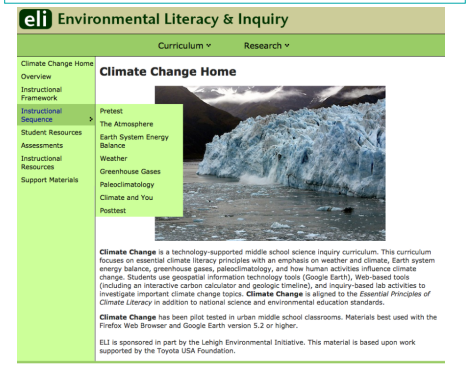
It is hoped that with a solid foundation of climate science in the classroom, middle school learners will be in a position to evaluate new scientific discoveries, emerging data sets, and reasonably assess information and misinformation by which they are surrounded on a daily basis.

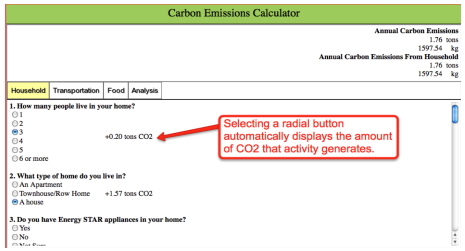
Pretests show that students:

- Do not understand that climate occurs on a time scale of decades (most think it is weeks or months)
-Do not know the main atmospheric contributors to global warming
-Do not understand the role of greenhouse gases as major contributors to increasing Earth's surface temperature
-Do not understand the role of water vapor to trap heat and add to the greenhouse effect
-Cannot identify some of the human activities that increase the amount of CO2
-Cannot identify sources of carbon emissions produced by US citizens
-Cannot describe human activities that are causing the long-term increase of carbon -dioxide levels over the last 100 years
-Cannot describe carbon reduction strategies that are feasible for lowering the levels of carbon dioxide in the atmosphere

Key Misunderstandings of Students:

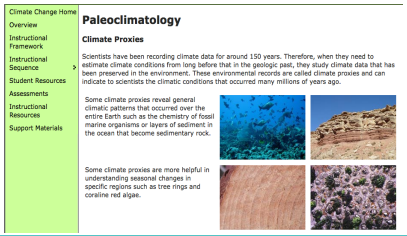
- Greenhouse gas sources and their composition in the atmosphere
- Unaware of the role of water vapor as a key greenhouse gas
- How the greenhouse effect works
- Erroneous cause-effect relationship between the greenhouse effect, global warming, and ozone layer depletion

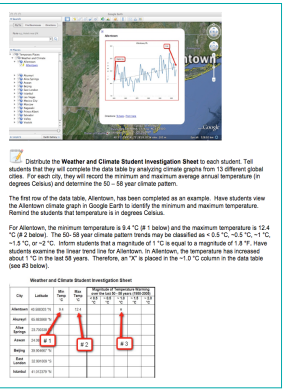




Support Materials

- Online reference content for teachers
- Teacher guides, assessment information, pedagogical implementation suggestions, visual guides





Findings:

- Post-test mean of the 28 multiple-choice items (16.91) on the Climate Literacy Assessment measure (Cronbach's alpha = .86) were significantly higher than pretest mean (11.24) t= 36.727, p<.001
- Large effect size: Cohen's d = 1.27
- Fidelity of implementation was high
  - Teachers frequently adhered to the entire instructional model
- High student engagement

Conclusions:

- Results indicated that the Climate Change curriculum was effective with supporting student learning of important concepts.
- Teacher response surveys indicated that the educative materials supported them with new ways of teaching climate change science content with a technology-integrated curriculum.
- Some misconceptions still persist with students.
  - More explicit instruction may be needed.
  - Additional year(s) of teacher curriculum enactment may enhance results.

Describe at least four different types of human activities that are causing the long-term increase of carbon dioxide levels over the last 100 years?

Category	Pretest	Post test
Transportation - Driving cars	537	729
Using electricity / Energy consumption habits	239	458
Burning fossil fuels	189	453
Cutting down trees/ deforestation	158	239
Pollution from factories and industries	127	147
Industrial Farming	64	116
Use more heat in the winter and air conditioning in the summer	166	169

What would it actually take for all the people on our planet to lower the levels of carbon dioxide in the atmosphere? List at least four ideas.

Category	Pretest	Posttest
Change transportation habits	413	629
Use renewable energy sources / Limiting fossil fuel energy use	154	287
Plant more trees / Stop deforestation / Stop cutting down trees	152	135
Reduce electricity use	143	274
Use less air conditioning in the summer and heat in the winter	98	121
Reduce energy use / Use less energy	57	154
Use more greener technologies in factories/ stop factories from polluting the air	23	48
Invent better fuel efficient cars	21	35
Other: Invent an efficient and clean energy producer; Make public transportation widely available; Invest in clean energy; Everyone using energy efficient appliances; Make inefficient cars taxed or even illegal	14	13

Climate Change curriculum:

http://www.ei.lehigh.edu/eli/cc

To access assessments, use:
Login: eliteacher
Password: 87dja92