A Collaboration Between Florida Atlantic University's Center for Environmental Studies and College of Education to Promote Climate and Sea Level Rise Education

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Integrating Climate Change and Argumentation in Elementary Science Methods Courses

A climate literate person…
- Understands the essential principles of Earth's climate system;
- Knows how to assess scientifically credible information about climate;
- Communicates about climate and climate change in a meaningful way; and
- Can make informed and responsible decisions with regard to actions that may affect climate change.

U.S. Global Research Program/Climate Science Program (2009)

Scientific evidence-based argumentation - the process of reasoning that requires a scientist to make a justified claim about the world, and in response, other scientists attempt to identify the claim's weaknesses, and limitations (National Research Council, 2011).

Argumentation has been identified as a mechanism for conceptual change (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Nussbaum & Sinatra, 2003).

Refutational (argumentative-based) lessons to address climate misinformation present a valuable opportunity to drive lasting conceptual change by addressing content concepts (way students conceive of knowledge) and epistemological concepts (way knowledge is produced).

INSTRUCTIONAL INTERVENTION AND RESEARCH

Pre-Assessments of Knowledge, Perceptions, and Scientific Argumentation and Inquiry
- Climate Science and Argumentation Instruction
- Climate Science Investigations (CSI) – Selected Lessons - www.ces.fau.edu/nasa
- Climate Change Study Guide and Reading Questions - http://www.coe.fau.edu/faculty/lambert/
- Analyzing the Nature of Scientific Inquiry in the Films, An Inconvenient Truth and Chasing Ice
- Culminating Scientific Argumentation Activity - Addressing Skeptics' Claims - http://www.ces.fau.edu/nasa/module-7/

Post-Assessments of Knowledge, Perceptions, and Scientific Argumentation and Inquiry

RESULTS OF STUDY

Students' Knowledge and Perceptions About Climate Change

		Mean	*SD*	*SEM*	*t*	*p**
Climate Science Knowledge	Pre	7.58	3.137	0.408	4.634	0.001
	Post	9.49	2.811	0.366		
Climate Change Concern/Importance	Pre	8.07	1.35	0.176	4.959	0.001
	Post	9.24	1.50	0.195		
Views on Climate Science (Causes and Impacts)	Pre	14.86	2.36	0.307	1.339	0.186
	Post	15.31	1.60	0.208		
Views on Climate Skepticism	Pre	11.98	1.71	0.222	3.604	0.001
	Post	13.19	2.45	0.318		

*Level of significance, knowledge, $p \leq 0.001$; perceptions, $p \leq .05$; $n = 59$

Students' knowledge of climate change increased significantly by the end of the course.

Students made the most gains in understanding the difference between weather and climate and the causes of recent global warming, but still had difficulty understanding some of the processes involved in the greenhouse effect and the carbon cycle.

Students' perceptions about climate change were significantly more aligned to those of climate scientists.

By the end of the course, more students believe that
- **human activity was the main cause of recent warming,**
- **they are already experiencing impacts of climate change,**
- **3-4°C of warming would be harmful to life on Earth, and**
- **extreme weather, water and food shortages, and people having to move away from some coastal cities will occur in the next 30 years.**

Students' Understanding of Scientific Argumentation and Inquiry

		Mean	*SD*	*SEM*	*t*	*p**
Nature of Scientific Argumentation	Pre	2.02	1.17	0.120	8.331	0.001
	Post	3.23	0.89	0.156		
Understanding of Scientific Inquiry	Pre	5.43	1.720	0.269	8.207	0.001
	Post	6.57	0.598	0.268		

*Level of significance, $p \leq .001$; $n = 59$

Overall, students' understanding of scientific argumentation and inquiry increased significantly after completing the course.

"Argumentation….
helps scientists eventually come to a consensus."
allows science to expand. Science is always changing and without argumentation there would be no challenging of ideas, changes, or advancements." (Student Quotes)

Students reported that the argumentation activity contributed most to their increased understanding of climate change.

Related Publications

- Lambert, J. & Bleicher, R. (2014). Improving climate change communication starting with environmental educators. Journal of Geoscience Education 62(3), 388-401.
- Lambert, J. & Bleicher, R. (2013). Climate change in the preservice teacher's mind. Journal of Science Teacher Education, 24, 999-1022.
- Lambert, J., Lindgren, J., & Bleicher, R. (2012). Assessing elementary science methods students' understanding about global climate change. International Journal of Science Education, 34(7-8), 1167-1188.

A FRAMEWORK FOR CLIMATE CHANGE INSTRUCTION INFORMED BY EDUCATIONAL RESEARCH

CLIMATE SCIENCE INVESTIGATIONS (CSI)

Home | About | Resources | References

Funded through NASA Innovations in Climate Education (NICE) program

The Nature of Science

Weather and Climate | Energy: The Driver of Climate | Temperature Over Time | Causes of Climate Change | Impacts of Climate Change | What We Can Do

Addressing Climate Skeptics' Claims

OVERVIEW OF CLIMATE SCIENCE INVESTIGATIONS (CSI)

Climate Science Investigations, an online, interactive curriculum, is a sequence of modules that serves as an innovative framework for teaching and learning about climate science over a semester timespan.

The curriculum is designed to enable upper level high school and early undergraduate students to analyze data available through various sources (e.g., NASA, NOAA, National Snow and Ice Data Center, U.S. Drought) and utilize tools (e.g., ArcGIS, Google Earth, Digital Coast) to address questions and about climate change.

NATURE OF SCIENCE

What practices do scientists engage in to reach consensus about climate change?

Core Science Concepts
- Nature of Scientific Inquiry
- Role of Skepticism in Science
- Evidence-Based Argumentation
- Scientific Consensus and Certainty

Scientists …	Detectives …
ask questions.	conduct inquires.
make systematic observations.	set up surveillance.
propose hypotheses.	follow their intuition and instinct (based on experience) to come up with likely scenarios.
collect, analyze, and interpret data.	(with help from forensic scientists) collect, analyze, and interpret evidence.
construct explanations, using evidence and reasoning to justify these explanations.	infer or deduce what happened based on the evidence collected.
evaluate or critique others' explanations.	investigate other leads to exclude all other possibilities and suspects.
communicate their research methods and results to other scientists and the public.	turn over their evidence and findings to prosecutors and the courts.

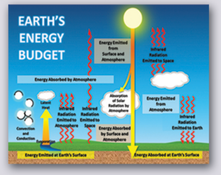
WEATHER AND CLIMATE

How do the methods used to study weather and climate differ?

Core Science Concepts
- Difference Between Weather and Climate
- Types of Climate
- Extreme Weather Events

ENERGY: THE DRIVER OF CLIMATE

How does the balance of incoming and outgoing energy affect Earth's climate?



Core Science Concepts
- Electromagnetic Radiation
- Heat Transfer
- Temperature and Radiation
- Earth's Energy Balance
- Greenhouse Effect
- Composition and Structure of the Atmosphere
- Difference Between Natural and Amplified Greenhouse Effect

TEMPERATURE OVER TIME

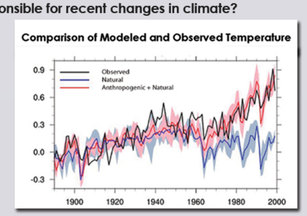
Is Earth's temperature increasing and is the recent trend unusual compared to temperature trends in the past?

Core Science Concepts
- Factors that Affect Temperature (Latitude, Angle of Solar Radiation, Seasons, Water, Ocean Currents, Elevation)
- Methods for Studying Past Temperature
- Temperature Change Over Geologic Time, Past 2,000 Years, and Since the Industrial Revolution.

CAUSES OF CLIMATE CHANGE

Are humans mostly responsible for recent changes in climate?

Core Science Concepts
- Natural Causes, (Milankovitch Cycles, Volcanic Eruptions, Solar Activity, ENSO)
- Anthropogenic Causes (Fossil Fuel Combustion, Changes in Land-Use, Cement Production)
- Radiative Forcings
- Carbon Cycle
- Climate Feedbacks
- Global Climate Models



IMPACTS OF CLIMATE CHANGE

What is the evidence that Earth has already warmed and what are the projected impacts to the planet and humans?

Core Science Concepts
- Observed and Projected Impacts for Different Emission Scenarios (Global Mean Temperature Increase, Land and Sea Ice Melt, Sea Level Rise)

WHAT WE CAN DO

What can we do to lessen and adapt to the impacts of climate change?

Core Science Concepts
- Mitigation, Adaptation
- Renewable Energy
- Stabilization Wedges
- Energy Consumption
- Environmental Policy

ADDRESSING CLIMATE SKEPTICS' CLAIMS

MODULE	EXAMPLES OF SKEPTICS' OVERARCHING CLAIM
The Nature of Science	There is no scientific consensus about causes of climate change.
Weather & Climate	Extreme weather events (such as precipitationand flooding, drought, heat waves) are not increasing, but just part of a normal cycle.
Energy: The Driver of Climate	The explanation of the greenhouse effect contradicts the second law of thermodynamics.
Temperature Over Time	Earth's climate (global average temperature) has changes in the past and recent changes are NOT unusual.
Causes of Climate Change	Natural variability is causing recent changes in temperature, not human activity.
Impacts of Climate Change	There is not enough evidence that Earth is warming. The impacts of a few degrees of global warming would NOT be that harmful to life (including humans) on Earth. Warming could even be good.
What We Can Do	Humans cannot reduce the effects of global warming even if it happening. It is too late to stop global warming, so we should adapt.

Framework for Climate Science Argumentation

Skeptics' Argument
(Claim, Evidence & Argumentation)

Scientists' Counter-Argument

Scientists' Counter-Claim

Evidence
The data that supports the scientific claim

Justification
The rationale or reasoning why each type of evidence warrants the scientific claim

Rebuttal to the Skeptics' Argument
The explanation that provides counter (scientific) evidence and reasoning for why the skeptics' explanation is not correct.

Evaluation (Critique) of Argument of Written/Oral Argument
- Provides appropriate and relevant evidence
- Justifies each type of evidence using scientific explanations
- Refutes the skeptics' argument with valid evidence, justification, and explanations
- References trustworthy scientific resources

Adapted from Toumlin's Argument Pattern (1958)

SHOULD WE STAY OR SHOULD WE GO?

A socio-environmental case study developed as part of a short-course, *Teaching Through Socio-Environmental Case Studies*, at the National Socio-Environmental Synthesis Center in Annapolis, Maryland.

SESYNC

SHOULD WE STAY? **OR SHOULD WE GO?**

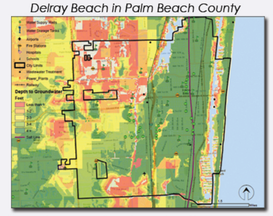
Porche Tower. Photo Credit: http://www.designtowermiami.com/

King Tide at the Stranahan House in Ft. Lauderdale. Photo Credit: Alana Edwards

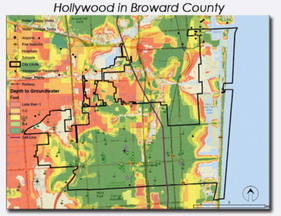
Socio-environmental case studies combine data and methods from the natural and social sciences to prepare students to address complex, transdisciplinary environmental problems.

In this case study,
- Each student assumes the primary role of a concerned citizen scientist living in one of four south Florida counties.
- Each student is also assigned to a county/city committee and to one of three stakeholder perspectives—water managers, residents, and business leaders.
- Using the cooperative learning jigsaw approach, students alternate meeting in county and stakeholder teams to analyze current articles, data, and GIS maps to identify the specific sea level related problems, socio-environmental impacts, and current/future adaptation strategies.
- Each county group ultimately makes recommendations to the city managers through a mock town hall meeting.

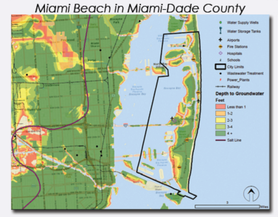
Delray Beach in Palm Beach County



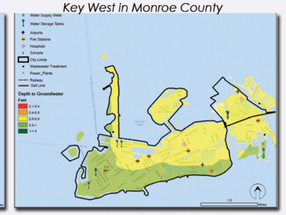
Hollywood in Broward County



Miami Beach in Miami-Dade County



Key West in Monroe County



Map Credit: Adam Chapman

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