Mapping DRK12 Project Activities to Climate and Environmental Literacy Principles

Steps Toward Leveraging Broader Impacts
Agenda

- Introduction
- Environmental Literacy Components - Hollweg
- Mapping Overview – EarthLabs - Ledley
- Mapping Climate & Environmental DRK12 Projects
  - Adventure Science - Dorsey
  - STEM Learning in the Context of Green School Buildings - Wilson
  - STORE - Zalles
  - Calipers II - Loveland
  - EcoMobile - Grotzer
- Discussion Question
- Next Steps
Discussion Question

Each of the projects presented describes how the effort addresses both the Climate Literacy Essential Principles of Climate Science (CLEP) and the Environmental Literacy Components (ELC).

In designing effective climate and environmental literacy efforts what is important to consider in the intersection of these two frameworks.
Next Steps?

• Climate and Environmental Literacy Special Interest Group (SIG) with support from Cadre – How might we want to move forward to leverage our efforts?

• Going beyond the DRK12 community
  ◦ Climate Literacy Network
  ◦ CLEAN Community
  ◦ Tri-agency Climate Change Education community
  ◦ Can we interact with/join these communities?
Developing a Framework for Assessing Environmental Literacy

Karen S. Hollweg, PI
June 15, 2012
DR K-12 PI Meeting, Arlington, VA
## Project Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Karen Hollweg</td>
<td>Principal Investigator</td>
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<tr>
<td>Jason Taylor</td>
<td>Project Coordinator</td>
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<td>Bill McBeth</td>
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<td>Rodger Bybee</td>
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<td>2006 &amp; 2015 PISA Committees</td>
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<tr>
<td>Pablo Zoido</td>
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<td>OECD, PISA</td>
</tr>
</tbody>
</table>
Experts at Workshop

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Dr. Libby McCann
Antioch University New England

Dr. Troy Sadler
University of Missouri

Dr. Paul C. Stern
National Research Council
Our 3 Products

► Definition of Environmental Literacy
► Components of Environmental Literacy
► A Proposed Framework for Assessing Environmental Literacy
An environmentally literate person is someone who, both individually and collectively with others, makes informed decisions concerning the environment, is willing to act on these decisions..., and participates in civic life.
Components of Environmental Literacy

► Knowledge
► Dispositions
► Competencies
► Behavior
Figure 1. The domain of environmental literacy

Knowledge

What you know about:
• Physical and ecological systems
• Social, cultural and political systems
• Environmental issues
• Multiple solutions to environmental issues
• Citizen participation and action strategies

Competencies

Skills and abilities that you know how and when to apply:
• Identify environmental issues
• Ask relevant questions about environmental conditions and issues
• Analyze environmental issues
• Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)
• Evaluate and make personal judgments about environmental issues (the interaction between environmental conditions and sociopolitical systems)
• Use evidence and knowledge to select and defend one’s own position(s) to resolve issues
• Create and evaluate plans at various scales/levels to resolve environmental issues

Dispositions

How you respond to environmental issues:
• Sensitivity
• Attitudes and concern toward the environment
• Assumption of personal responsibility
• Locus of control/ Self-efficacy
• Motivation, intention to act

Feedback/reflection loop continued literacy development

Environmentally Responsible Behavior

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones.

Contexts

Personal, Social, and Physical

Figure 1. The domain of environmental literacy
A proposed framework for assessing environmental literacy – PISA 2015

Contexts

Local, regional, or global situations that involve the environment

Competencies

Identify environmental issues.
Analyze environmental issues.
Evaluate potential solutions to environmental issues.
Propose & justify actions that address the environmental issue.

Environmental Knowledge

What you know about:
• the physical, ecological system,
• environmental issues,
• sociopolitical systems,
• strategies for addressing environmental issues.

Dispositions toward the Environment

How you respond to environmental issues:
• interest,
• sensitivity,
• locus of control,
• responsibility,
• intention to act.
**What an assessment framework is**

<table>
<thead>
<tr>
<th>is...</th>
<th>is not...</th>
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<tr>
<td>• guidance for people creating an assessment (i.e., test items &amp; survey questions)</td>
<td>• a test or specific questions that should be asked</td>
</tr>
<tr>
<td>• components &amp; contexts to be assessed, based on research</td>
<td>• standards or guidelines for what should be in a curriculum</td>
</tr>
<tr>
<td>• specifications re: the % and types of items for each component</td>
<td>• teaching strategies</td>
</tr>
</tbody>
</table>
Confronting the Challenges of Climate Literacy

Tamara Shapiro Ledley & Nick Haddad, TERC
Karen McNeal, Mississippi State University
Kathy Ellins, University of Texas Austin
Julie Libarkin, Michigan State University

EarthLabs for Educators and Policy Makers

Teachers Guide: http://serc.carleton.edu/earthlabs;
Student Portal: http://serc.carleton.edu/eslabs
What Is EarthLabs?

- Laboratory Component of a High-School Capstone Course in Earth and Space Science
- Modules have 5-9 labs; 3 weeks long
- Previously funded modules
  - NOAA – Environmental Literacy
    - Hurricanes, Drought, Fisheries, Corals
  - NASA – Climate Change Education
    - Earth System Science
- NSF-DRK12 Funded Modules
  - Climate and the Cryosphere
  - Climate, Weather, and the Biosphere
  - Carbon and the Earth System
  - Research question focused on students understanding of change over time on multiple and embedded time scales
<table>
<thead>
<tr>
<th>EP 1: The sun is the primary source of energy for Earth’s climate system</th>
<th>EP 2: Climate is regulated by complex interactions among components of the Earth system</th>
<th>EP 3: Life on Earth Depends on, is shaped by, and affects climate</th>
<th>EP 4: Climate varies over space and time through both natural and man-made processes.</th>
<th>EP 5: Our understanding of the climate system is improved through observations, theoretical studies and modeling</th>
<th>EP 6: Human activities are impacting the climate system</th>
<th>EP 7: Climate change will have consequences for the Earth system and human lives</th>
<th>Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts</th>
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<tr>
<td>Sunlight warms the planet</td>
<td>Interactions of Sun and Earth system</td>
<td>Organisms adapt, migrate or perish</td>
<td>Earth's climate system is subject to physical laws of the universe</td>
<td>Humans likely caused global temperature increases</td>
<td>Climate is not the same as weather</td>
<td>Thermal expansion &amp; melting ice causing sea level rise</td>
<td>Climate science can inform policy and decision making</td>
</tr>
<tr>
<td>Earth energy balance</td>
<td>Hydrosphere, energy and climate</td>
<td>Heat-trapping gases warm Earth’s surface supporting liquid water</td>
<td>Climate is not the same as weather</td>
<td>Observations are key to understanding climate</td>
<td>Increased GHG concentrations is long term and will impact future climate</td>
<td>Changing climate alters the water cycle and freshwater availability</td>
<td>Reducing climate change impacts requires multi-disciplinary understanding</td>
</tr>
<tr>
<td>Reasons for the seasons</td>
<td>Greenhouse gases from outgoing IR heat</td>
<td>Changes in climate affect ecosystems and species</td>
<td>Climate change is a change in average climate conditions</td>
<td>Observations, experiments, and theory refine computer models</td>
<td>Human activities have altered global climate patterns</td>
<td>Extreme Weather events are projected to increase</td>
<td>Climate change affects global/national security</td>
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<tr>
<td><strong>EP 1D</strong></td>
<td><strong>EP 2D</strong></td>
<td><strong>EP 3D</strong></td>
<td><strong>EP 4D</strong></td>
<td><strong>EP 5D</strong></td>
<td><strong>EP 6D</strong></td>
<td><strong>EP 7D</strong></td>
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<td>Orbital Cycles</td>
<td>Biogeochemical/Carbon cycles</td>
<td>Past 10,000 years have been unusual</td>
<td>Climate is normal but varies over timespace</td>
<td>Our understanding of climate and weather differ</td>
<td>Changes in physical and biological systems linked to human caused climate change</td>
<td>Ocean becoming more acidic impacting marine species</td>
<td>Humans may be able to mitigate climate change</td>
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<tr>
<td>Solar Variability</td>
<td>Particulates’ impact climate</td>
<td>Life can influence global climate</td>
<td>Observations show temperatures have increased over past 50 yrs.</td>
<td>Climate change projections help with potential decisions and actions</td>
<td>Negative impacts are likely to outweigh positive impacts</td>
<td>Ecosystems are disturbed by climate change</td>
<td>Strategies needed to reduce greenhouse gases</td>
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<td>Feedback systems</td>
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<td>Evidence that humans have a role in climate change</td>
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<td>Strategies need to adaptation to climate change</td>
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<td>Uncategorized</td>
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Figure 1. The domain of environmental literacy – EarthLabs: Climate, Weather & Biosphere

**Knowledge**

- What you know about:
  - Physical and ecological systems
  - Social, cultural and political systems
  - Environmental issues
  - Multiple solutions to environmental issues
  - Citizen participation and action strategies

**Dispositions**

- How you respond to environmental issues:
  - Sensitivity
  - Attitudes and concern toward the environment
  - Assumption of personal responsibility
  - Locus of control/ Self-efficacy
  - Motivation, and intention to act

**Competencies**

- Skills and abilities that you know how and when to apply:
  - Identify environmental issues
  - Ask relevant questions about environmental conditions and issues
  - Analyze environmental issues
  - Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)
  - Evaluate and make personal judgments about environmental issues (the interaction between environmental conditions and sociopolitical systems)
  - Use evidence and knowledge to select and defend one’s own position(s) to resolve issues
  - Create and evaluate plans at various scales/levels to resolve environmental issues

**Contexts**

- Personal, Social, and Physical

**Environmentally Responsible Behavior**

- Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones.

**Feedback/reflection loop continued literacy development**

*Figure 1 cont.*
Climate, Weather, and the Biosphere

1. Climate, Weather, and Trees
2. Earth’s Energy Balance
3. Climatology Basics
4. Climate and Life Patterns
5. Extreme Weather
6. Trees and Paleoclimate
7. Future of the Forest
Lab 1: Climate Weather and Trees

http://serc.carleton.edu/dev/eslabs/weather/1.html

- Students examine the relationship between climate, weather and plants in their own region.
- Case Study: Sugar Maple Trees – Vermont
- Suitable climate conditions for a Sugar Maple forest
- Conditions under which Sugar Maple sap flows
- Lab 7: Future of the Forest
  - Maple Syrup and Climate Change
  - Suitable Trees for your home region

Addresses EP3A and EP3C, & 3 ELC Competencies
Lab 2B: Follow the Energy Flow

http://serc.carleton.edu/dev/eslabs/weather/2b.html

- Multiple avenue to explore the movement of energy through the Earth system
  - Wire diagram interactive
  - Global energy balance interactive
  - Traditional energy balance diagram
  - Hands on accounting for the energy

Addresses EP1A and EPIB & 3 ELC Compenencies
What will Earth’s climate be in the future?

- Compelling unanswered science questions
- Interactive, first-principle models
- Examples using real-world data
- Video interviews of practicing scientists
- Embedded explanation-certainty assessments
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<td>Natural processes do not explain rapid climate change</td>
<td>Earth's climate system is subject to physical laws of the universe</td>
<td>Climate is not the same as weather</td>
<td>Observations are key to understanding climate</td>
<td>Burning fossil fuels increases the greenhouse gases in the atmosphere</td>
<td>Observations, experiments, and theory refine computer models</td>
<td>Human activities have altered global climate patterns</td>
<td>Extreme Weather events are projected to increase</td>
<td>The chemistry of ocean water is becoming more acidic</td>
<td>Climate change Mitigation</td>
<td>Strategies to reduce greenhouse gases</td>
<td>Human health will be affected by climate change</td>
<td>Adaptation to climate change</td>
<td>Reduction of society</td>
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**Guiding Principle for informed climate decision:**
Humans can take actions to reduce climate change and its impacts.

**Guiding Principle for informed climate decision:**
- Reduce vulnerability/Enhance resilience
- Integrating climate knowledge
- Security of nations
- Climate change Mitigation
- Strategies to reduce greenhouse gases
- Human health will be affected by climate change
- Adaptation to climate change
- Reduction of society
**EP 2: Climate is regulated by complex interactions among components of the Earth system**

<table>
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<th>EP 1: The sun is the primary source of energy for Earth's climate system</th>
<th>EP 2: Climate is regulated by complex interactions among components of the Earth system</th>
<th>EP 4: Climate understanding (fundamentals)</th>
<th>EP 5: Our understanding of climate change</th>
<th>EP 6: Climate change (impacts)</th>
<th>EP 7: Climate change (mitigation)</th>
<th>Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts</th>
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<td>Earth energy balance</td>
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<td>Hydrosphere, energy and climate</td>
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<td>Average temperatures have increased in the past 50 years</td>
<td>EP 5D</td>
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<td>Solar Variability</td>
<td>EP 2E</td>
<td>Particulates' impact climate</td>
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<td>Natural processes do not explain rapid climate change</td>
<td>EP 5E</td>
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<td>EP 1F</td>
<td>Feedback systems</td>
<td>EP 2F</td>
<td>Life can influence global climate</td>
<td>EP 4F</td>
<td>Natural processes do not explain rapid climate change</td>
<td>EP 5F</td>
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</table>
Figure 1. The domain of environmental literacy

Knowledge

What you know about:
- Physical and ecological systems
  - Social, cultural and political systems
  - Environmental issues
  - Multiple solutions to environmental issues
  - Citizen participation and action strategies

Dispositions

How you respond to environmental issues:
- Sensitivity
- Attitudes and concern toward the environment
- Assumption of personal responsibility
- Locus of control/ Self-efficacy
- Motivation, and intention to act

Competencies

Skills and abilities that you know how and when to apply:
- Identify environmental issues
- Ask relevant questions about environmental conditions and issues
- Analyze environmental issues
  - Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)
  - Evaluate and make personal judgments about environmental issues (the interaction between environmental conditions and sociopolitical systems)
- Use evidence and knowledge to select and defend one’s own position(s) to resolve issues
  - Create and evaluate plans at various scales/levels to resolve environmental issues

Feedback/reflection loop
continuing literacy development

Environemntally Responsible Behavior

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new
Brief Descriptions of the Competencies

**Identify environmental issues** – including the ability to describe and provide evidence for the dimensions of the issue, human disagreements central to it, factors that cause or contribute to it.

**Ask relevant questions** – about environmental problems as well as human dimensions and historical or geographical features of an issue. Also the ability to ask higher-order questions aimed at discovering conditions that have implications for the issue.

**Analyze environmental issues** – the interpretation and use of knowledge regarding physical, ecological & sociopolitical systems, and of information about stakeholders, their positions, beliefs and value perspectives. Also, the ability to determine relevant factors and to discern interactions among those factors, and to predict likely consequences of issues.

**Investigate environmental issues** – by gathering new information about an issue as well as locating and using relevant sources of additional information, synthesizing, and communicating the outcomes of the investigation.

**Evaluate & make personal judgments about environmental issues** – constructing dispassionate evaluations and explanations based on available information & the beliefs and values of stakeholders; and articulating views about actions that may be warranted.

**Use evidence & experience to defend positions & resolve issues** – constructing and defending a sound evidence-based argument about what it will take to resolve or help resolve an issue.

**Create and evaluate plans to resolve environmental issues** – by assuming the responsibility for acting, frequently with others, and engaging in planning based on the environmental conditions, available resources, and sociopolitical contexts to resolve or help resolve issues.
Red is temperature change from the starting temperature.

Green is CO₂ in air (in ppm)
Blue is CO₂ in oceans

Follow an energy packet
Hide current gases
Follow a greenhouse gas
Hide current rays
Red is temperature rise from the starting temperature. Blue indicates the amount of water vapor in the air.

Green is CO2 in air (in ppm)
Blue is CO2 in oceans

Follow an energy packet  Follow a greenhouse gas  Hide current gases  Hide current rays
How might the trend shown in the graph affect Earth's temperature in the year 2100?

- It will increase the temperature.
- It will decrease the temperature.
- There will be no effect on the temperature.

Explain your prediction.

On a scale from 1 to 5, how certain are you about your temperature prediction for the future?

- (1) Not at all certain
- (2)
- (3)
- (4)
- (5) Very certain

Explain what affects your level of certainty about your prediction for temperature change.
The image shows a theoretical model of climate change, likely from a scientific simulation or educational software. The model includes various elements and controls for adjusting the environment's temperature and greenhouse gas levels. Here are the key features:

- **Temp Change**: The model allows for adjusting temperature changes over time. Legends and data points indicate changes since the year 2010.
- **Air Temp Change** and **Ocean Temp Change**: These specific temperature changes are quantifiable and can be adjusted.
- **Greenhouse Gases**: The model tracks CO2 and water vapor concentrations over time.
- **Follow an energy packet** and **Follow a greenhouse gas**: Interactive options to explore specific elements within the simulation.
- **Hide current gases** and **Hide current rays**: Additional controls for adjusting the visual representation of the model.

The simulation likely uses a combination of graphs, temperature charts, and interactive elements to illustrate the impacts of human-emission levels on environmental changes.
The most urgent issue facing climate modelers today is the effect of humans on Earth's temperature.

Run the model and adjust the "Human-emission" slider to determine how much humans would need to change their CO₂ emissions (as compared to 2010 emissions) to significantly reduce global temperature.

**How much did you need to change human emissions to reduce the average global temperature?**

**Explain your conclusion by describing the experiments that you have run and their outcomes.**
Green Schools Project

GOAL: to plan the development of STEM curriculum for the middle grades with these features:

- Math and science learning goals as foci
- Data from green school buildings
- Motivate future STEM learning
- Kids solving complex problems
- Innovative, transformative uses of formal, informal education
Scope and Sequence of Curriculum
6-8
What you know about:
- **Physical** and ecological systems
- Social, cultural and political systems
- Environmental issues
- Multiple solutions to environmental issues
- Citizen participation and action strategies

How you respond to environmental issues:
- Sensitivity
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- **Create and evaluate plans at various scales/levels to resolve environmental issues**

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones.

**Knowledge**

**Dispositions**

**Competencies**

**Environmentally Responsible Behavior**

**Contexts**

Personal, Social, and Physical

Feedback/reflection loop continued literacy development

Figure 1. The domain of environmental literacy
Clep mapping

**EP 1 C**
Reasons for the seasons

**GP E**
Strategies to reduce greenhouse gases

**GP G**
Action-all levels of society
Studying Topography, Orographic Rainfall, and Ecosystems with Geospatial Information Technology

Dan Zalles, PI
Jim Manitakos, Co-PI
Center for Technology and Learning, SRI International

Contact: dan.zalles@sri.com
http://store.sri.com

Funding for the Studying Topography, Orographic Rainfall, and Ecosystems with Geospatial Information Technology Project is provided by National Science Foundation DRL Grant 1019645
Figure 1. The domain of environmental literacy

**Knowledge**

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**Contexts**

Personal, Social, and Physical

Feedback/reflection loop continued literacy development

Feedback/reflection loop continued literacy development

Figure 1. The domain of environmental literacy
Climate Literacy Essential Principles

- **EP 2:** Climate is regulated by complex interactions among components of the Earth system
  - Hydrosphere, energy and climate
  - Feedback systems

- **EP 3:** Life on Earth Depends on, is shaped by, and affects climate
  - Organisms adapt, migrate or perish
  - Changes in climate affect ecosystems and species

- **EP 5:** Our understanding of the climate system is improved through observations, theoretical studies and modeling
  - Observations are key to understanding climate
  - Climate change projections help with potential decisions and actions

- **EP 6:** Human activities are impacting the climate system
  - Humans likely caused global temperature increases

- **EP 7:** Climate change will have consequences for the Earth system and human lives
  - Changing climate alters freshwater resources
  - Ecosystems are disturbed by climate change
Physical and ecological systems
- Changing climate alters freshwater resources
- Ecosystems are disturbed by climate change

CURRICULM MODULE EXEMPLAR (6 Core lessons)
• Basic Lesson 1: Learn key meteorological principles
• Basic Lesson 2: Study temperature and precipitation changes in California study area
• Basic Lesson 3: Compare mean annual precipitation and for weather stations along transect and compare ground surface temperature lapse rates to atmospheric lapse rates
• Basic Lesson 4: Explore how regional climate affects vegetation
• Advanced Lesson 1: Compare projected 2050 precipitation to most recent precipitation 30-year climatology and 2050 spatial distribution of regional vegetation communities
• Advanced Lesson 2: Same as Advanced Lesson 1, but about temperatures
1. Assuming that the tolerance range for each vegetation type does not change between now and the year 2050, evaluate how the projected temperature changes will affect vegetation in each region. Discuss and describe which regions will have vegetation changes, and give numerical evidence to support your conclusions.

2. Of course, organisms do adapt to changes in environment through their ability to migrate to more suitable regions and via the process of natural selection. In this case:
   A. Describe the process by which plants “migrate” to other regions. Do you think there will be enough time for vegetation to migrate to a more suitable climate while climate change is occurring?
   B. Briefly describe how selection pressure changes the vegetation’s gene pool. Do you think there will be enough time to allow for adaptation to the changed climate? Cite specific evidence and data to support your conclusion.

3. Based upon the expected change in vegetation, describe the impact to food webs in habitats near each of the 5 weather stations. Give specific examples to support your conclusion.

4. Now, look at the two enclosed world maps showing global predictions for sea level, precipitation and temperature changes under the IPCC A2 scenario.
   A. What part of the world shows the greatest impact? Will very many people notice this change?
   B. What challenge will Europe face with both increased temperature and less rainfall?
   C. What will the impact be in Asia?

5. Based upon the variability in impact of climate change, would citizens of each region agree on the importance of trying to minimize climate change? Explain and justify your conclusion.
What you know about:
• Physical and ecological systems
• Social, cultural and political systems
• Environmental issues
• Multiple solutions to environmental issues
• Citizen participation and action strategies

How you respond to environmental issues:
• Sensitivity
  • Attitudes and concern toward the environment
  • Assumption of personal responsibility
  • Locus of control/ Self-efficacy
  • Motivation, and intention to act

Skills and abilities that you know how and when to apply:
• Identify environmental issues
• Ask relevant questions about environmental conditions and issues
• Analyze environmental issues
• Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)
• Evaluate and make personal judgments about environmental issues (the interaction between environmental conditions and sociopolitical systems)
• Use evidence and knowledge to select and defend one’s own position(s) to resolve issues
• Create and evaluate plans at various scales/levels to resolve environmental issues

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones.

Feedback/reflection loop
continued literacy development

Knowledge

Competencies

Dispositions

Environmentally Responsible Behavior

Contexts

Personal, Social, and Physical

Figure 1. The domain of environmental literacy
Calipers II: Using Simulations to Assess Complex Science Learning - Goals -

1. Develop simulation-based assessment modules to supplement and extend the science knowledge and skills typically addressed in static print materials

2. Foster deep learning about science systems and use of inquiry practices

3. Document the effectiveness, feasibility, and utility of simulation-based science environments for promoting and assessing science standards
The Domain of Environmental Literacy

Knowledge
What you know about:
- Physical and ecological systems
  - Social, cultural and political systems
  - Environmental issues
  - Multiple solutions to environmental issues
  - Citizen participation and action strategies

Dispositions
How you respond to environmental issues:
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Environmentally Responsible Behavior
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Feedback/reflection loop
continued literacy development

Contexts
Personal, Social, and Physical

Feedback/reflection loop
continued literacy development

Contexts
Personal, Social, and Physical
**Climate Literacy: The Essential Principles of Climate Science**

<table>
<thead>
<tr>
<th></th>
<th>EP 1: The sun is the primary source of energy for Earth’s climate system</th>
<th>EP 2: Climate is regulated by complex interactions among components of the Earth system</th>
<th>EP 3: Life on Earth depends on, is shaped by, and affects climate</th>
<th>EP 4: Climate varies over space and time through both natural and man-made processes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP 1 A</td>
<td>Sunlight warms the planet</td>
<td>Interactions of Sun and Earth systems</td>
<td>Organisms adapt, migrate or perish</td>
<td>Climate is long term</td>
</tr>
<tr>
<td>EP 1 B</td>
<td>Earth energy balance</td>
<td>Hydrosphere, energy and climate</td>
<td>Heat-trapping gases warm Earth’s surface</td>
<td>Climate is not the same as weather</td>
</tr>
<tr>
<td>EP 1 C</td>
<td>Reasons for the seasons</td>
<td>Greenhouse gases trap outgoing IR heat</td>
<td>Changes in climate affect ecosystems and species</td>
<td>Climate change is a change in average climate conditions</td>
</tr>
</tbody>
</table>
## Calipers II: Climate - System Model Levels -

<table>
<thead>
<tr>
<th>Components</th>
<th>Target Label (for the LMS)</th>
<th>Features</th>
<th>Principles</th>
<th>Elements Tagging Level + Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Components</strong></td>
<td>1. Earth System</td>
<td>Energy</td>
<td>The Sun provides the vast majority of energy to the Earth.</td>
<td>1.1 Solar Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earth</td>
<td>Earth has a hydrosphere, an atmosphere, and a lithosphere.</td>
<td>1.2 Hydrosphere</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Differential</td>
<td>Differences in the surface materials, greenhouse gas concentrations and amounts of insolation produce differential heating at different latitudes and times of year.</td>
<td>1.3 Atmosphere</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heating</td>
<td></td>
<td>1.4 Lithosphere</td>
</tr>
<tr>
<td><strong>Interactions</strong></td>
<td>2. Energy Flows</td>
<td>Regional</td>
<td>The major influence on regional climate patterns is incoming solar energy which is determined by latitude, but other features of a location also influence its climate.</td>
<td>2.1 Variable Incoming Solar Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Climates</td>
<td></td>
<td>2.2 Absorption/Reflection/Radiation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.3 Greenhouse Effect</td>
</tr>
<tr>
<td><strong>Emergent Phenomena</strong></td>
<td>3. Climate</td>
<td>Regional</td>
<td></td>
<td>3.1 Regional Climate Definition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Climates</td>
<td></td>
<td>3.2 Factors Affecting Regional Climate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.3 Regional Climate Patterns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Global Climate</td>
<td></td>
<td>3.4 Global Climate</td>
</tr>
</tbody>
</table>
Multiple Modes of Representation
- Active Inquiry -

Earth View

Horizon View

Graph shows incoming solar energy over course of a day

Table shows values for latitude, date, time of day, and incoming solar energy
EcoMOBILE: Blended Learning Across Virtual and Natural Ecosystems

Co: PIs: Chris Dede and Tina Grotzer
Amy M. Kamarainen
Shari J. Metcalf
What is EcoMOBILE?

- Builds on concepts from CAREER: Causal Learning in the Classroom (NSF#0845632 to Grotzer) and earlier work.
- Includes EcoMUVE (IES#R305A080514 to Dede and Grotzer)
- Adds Augmented Reality (AR) as an immersive interface utilizing mobile, context-aware technologies and software that enables participants to interact with digital information embedded within the physical environment and to build on the MUVE.
A student using a visual target to see a 3-D image on the smartphone.
What you know about:
- **Physical and ecological systems**
- Social, cultural and political systems
- Environmental issues
- Multiple solutions to environmental issues
- Citizen participation and action strategies

How you respond to environmental issues:
- Sensitivity
- Attitudes and concern toward the environment
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  - Use evidence and knowledge to select and defend one’s own position(s) to resolve issues
- **Create and evaluate plans at various scales/levels to resolve environmental issues**

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones.
# Climate Literacy: The Essential Principles of Climate Science

<table>
<thead>
<tr>
<th>Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts</th>
<th>EP 1: The sun is the primary source of energy for Earth's climate system</th>
<th>EP 2: Climate is regulated by complex interactions among components of the Earth system</th>
<th>EP 3: Life on Earth depends on, is shaped by, and affects climate</th>
<th>EP 4: Climate varies over space and time through both natural and man-made processes</th>
<th>EP 5: Our understanding of the climate system is improved through observations, theoretical studies, and modeling</th>
<th>EP 6: Human activities are impacting the climate system</th>
<th>EP 7: Climate change will have consequences for the Earth system and human lives</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP 1 B: Earth energy balance</td>
<td>EP 2 B: Interactions of Sun and Earth systems</td>
<td>EP 3 B: Heat-trapping gases warm Earth's surface</td>
<td>EP 4 B: Climate is not the same as weather</td>
<td>EP 5 B: Observations are key to understanding climate</td>
<td>EP 6 B: Changes in climate alter freshwater resources</td>
<td>EP 7 B: Burning fossil fuels increases the greenhouse gases in the atmosphere</td>
<td></td>
</tr>
<tr>
<td>EP 1 C: Reasons for the seasons</td>
<td>EP 2 C: Greenhouse gases trap outgoing IR heat</td>
<td>EP 3 C: Changes in climate affect ecosystems and species</td>
<td>EP 4 C: Climate change is a change in average climate conditions</td>
<td>EP 5 C: Observations, experiments, and theory refine computer models</td>
<td>EP 6 C: Human activities have altered global climate patterns</td>
<td>EP 7 C: Extreme weather events are projected to increase</td>
<td></td>
</tr>
<tr>
<td>EP 1 D: Orbital Cycles</td>
<td>EP 2 D: Life is possible on other planets</td>
<td>EP 3 D: Past 10,000 years have been unusual</td>
<td>EP 4 D: Average temperatures have increased in the past 50 years</td>
<td>EP 5 D: Many human systems are linked to climate change</td>
<td>EP 6 D: The chemistry of ocean water is becoming more acidic</td>
<td>EP 7 D: Climate change Mitigation</td>
<td></td>
</tr>
</tbody>
</table>
Acknowledgments

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TI Nspire graphing calculators with Vernier probes were provided by Texas Instruments, Inc.
The augmented reality activities were developed using the FreshAiR AR development platform by MoGo Mobile, Inc.

For more information, visit our website at ecomobile.gse.harvard.edu
Discussion Question

Each of the projects presented describes how the effort addresses both the Climate Literacy Essential Principles of Climate Science (CLEP) and the Environmental Literacy Components (ELC).

In designing effective climate and environmental literacy efforts what is important to consider in the intersection of these two frameworks.
Next Steps?

- Climate and Environmental Literacy Special Interest Group (SIG) with support from Cadre – How might we want to move forward to leverage our efforts?

- Going beyond the DRK12 community
  - Climate Literacy Network  [http://cleanet.org/cln](http://cleanet.org/cln)
  - Tri-agency Climate Change Education community  [https://nice.larc.nasa.gov/tri_pi/](https://nice.larc.nasa.gov/tri_pi/)
  - Can we interact with/join these communities?