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

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Our 3 Products

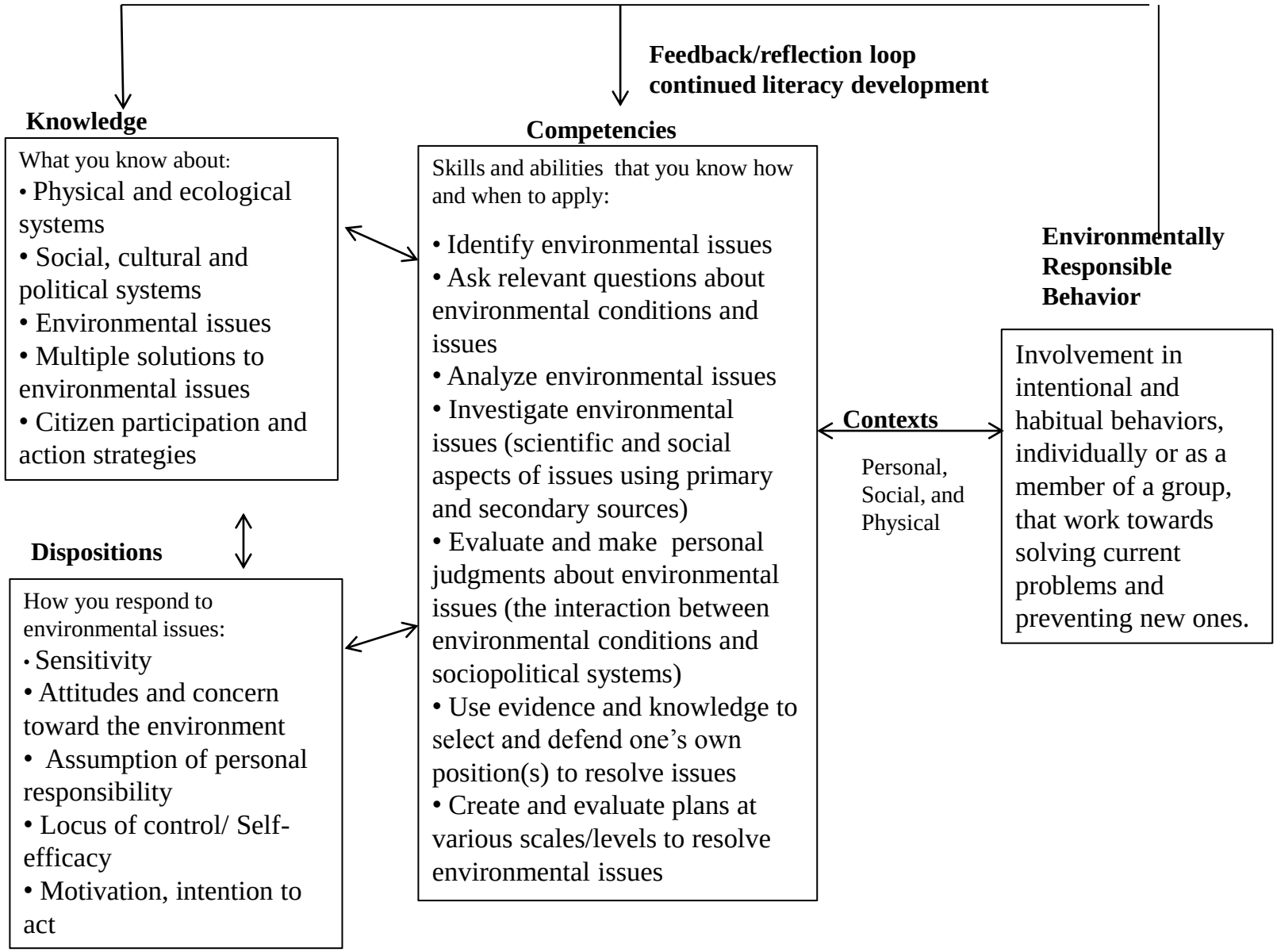
- Definition of Environmental Literacy
- Components of Environmental Literacy
- A Proposed Framework for Assessing Environmental Literacy

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.

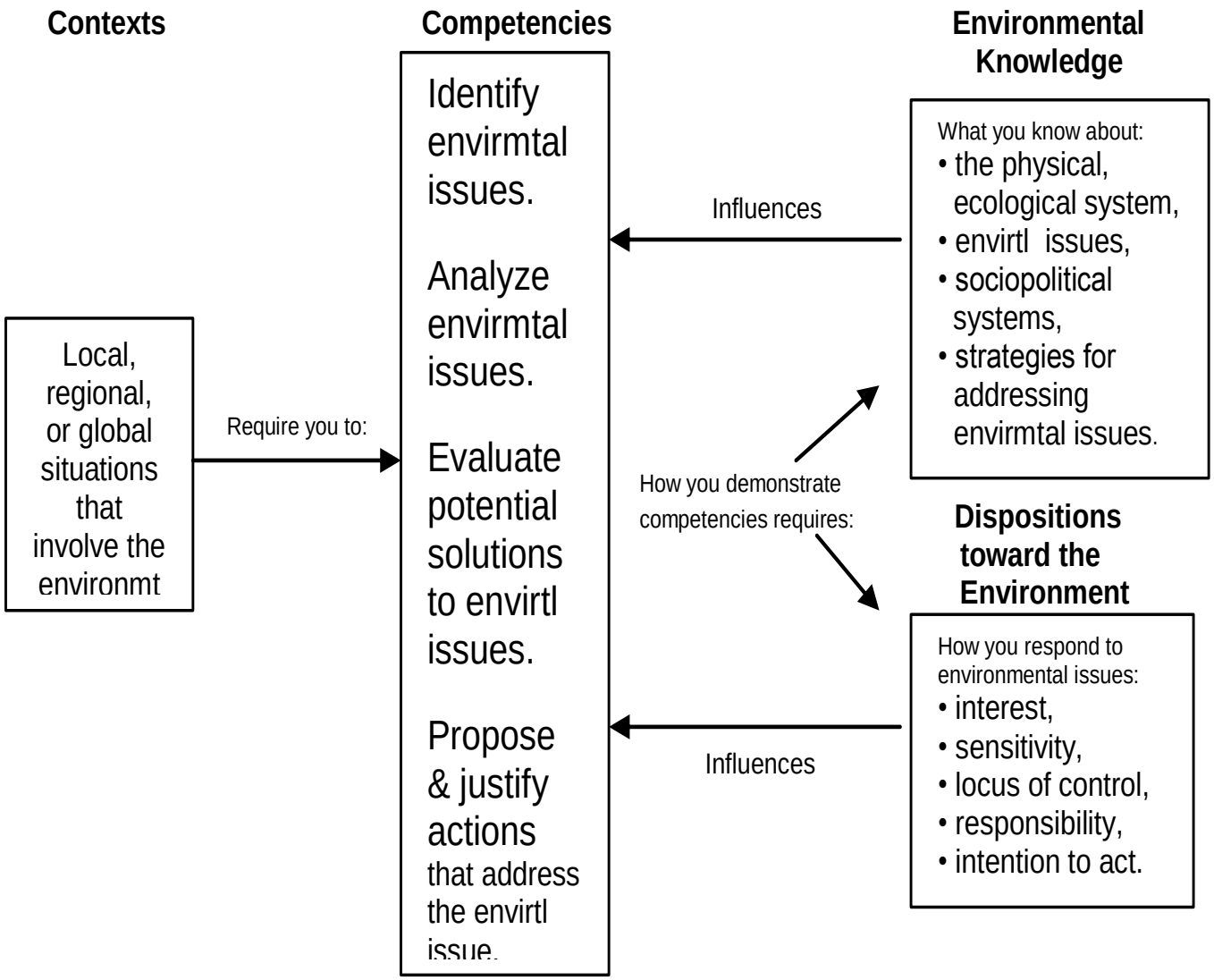
Components of Environmental Literacy

- Knowledge
- Dispositions
- Competencies
- Behavior

Figure 1. The domain of environmental literacy



A proposed framework for assessing environmental literacy – PISA 2015



What an assessment framework

is…	**is <u>not</u>**…
• guidance for people creating an assessment (i.e., test items & survey questions) • components & contexts to be assessed, based on research • specifications re: the % and types of items for each component	• a test or specific questions that should be asked • standards or guidelines for what should be in a curriculum • teaching strategies

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

a National Model for Earth Science Lab Courses

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

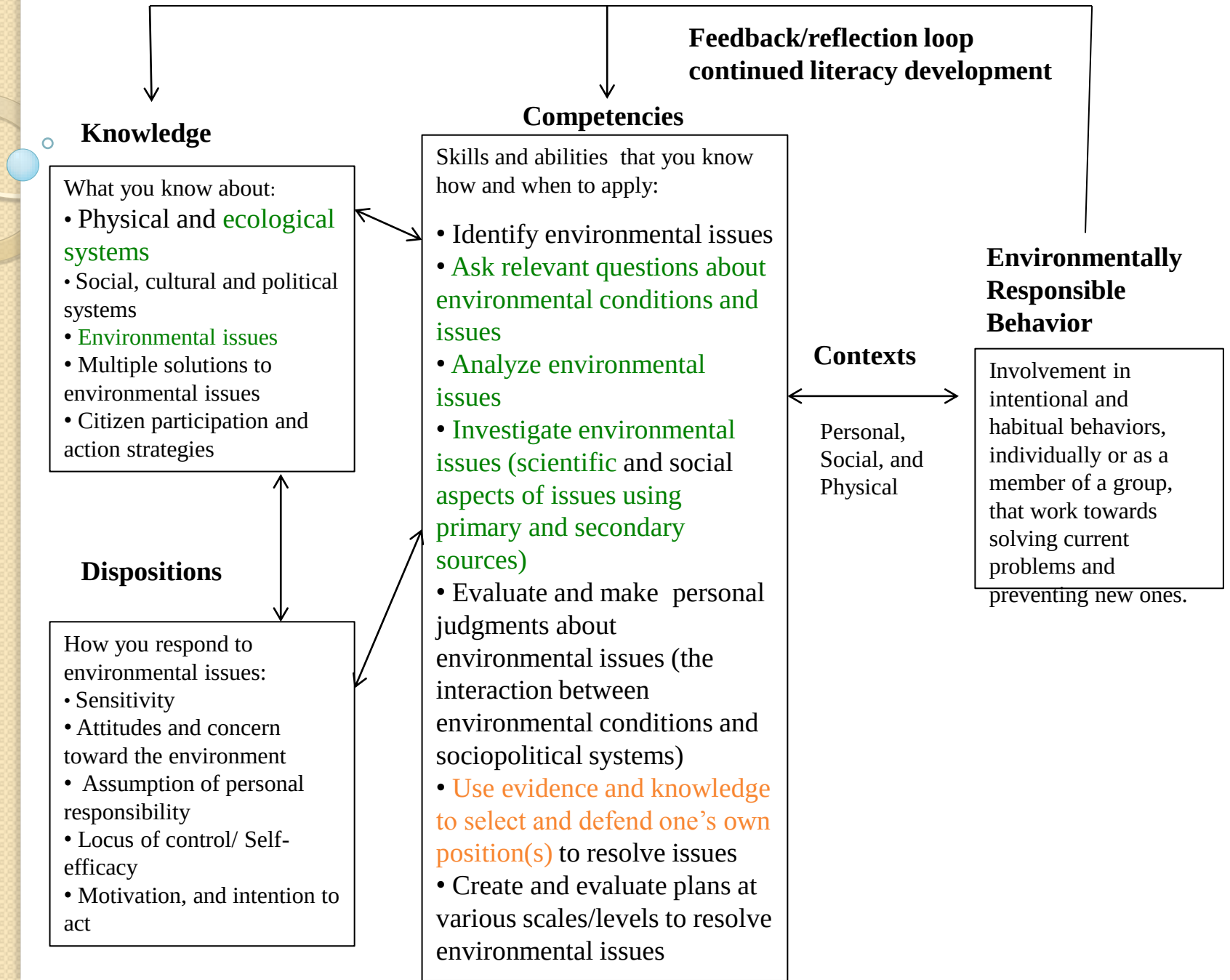
Climate Literacy: The Essential Principles of Climate Science

Climate, Weather and the Biosphere – EarthLabs Module

Module addresses in-depth, Module is supportive

EP 1: The sun is the primary source of energy for Earth's climate system	EP 2: Climate is regulated by complex interactions among components of the Earth system	EP3: Life on Earth Depends on, is shaped by, and affects climate	EP4: Climate varies over space and time through both natural and man-made processes.	EP 5: Our understanding of the climate system is improved through observations, theoretical studies and modeling	EP 6: Human activities are impacting the climate system	EP 7: Climate change will have consequences for the Earth system and human lives	Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts
EP 1 A Sunlight warms the planet	**EP 2 A** Interactions of Sun and Earth systems	**EP 3A** Organisms adapt, migrate or perish	**EP 4A** Climate is long term	**EP 5A** Earth's climate system is subject to physical laws of the universe	**EP 6A** Humans likely caused global temperature increases	**EP 7A** Thermal expansion & melting ice causing sea level rise	**GP A** Climate science can inform policy and decision making
EP 1B Earth energy balance	**EP 2B** Hydrosphere, energy and climate	**EP 3B** Heat-trapping gases warm Earth's surface supporting liquid water	**EP 4B** Climate is not the same as weather	**EP 5B** Observations are key to understanding climate	**EP 6B** Increased GHG concentrations is long term and will impact future climate	**EP 7B** Changing climate alters the water cycle and freshwater availability	**GP B** Reducing climate change impacts requires multi-disciplinary understanding
EP 1C Reasons for the seasons	**EP 2C** Greenhouse gases trap outgoing IR heat	**EP 3C** Changes in climate affect ecosystems and species	**EP 4C** Climate change is a change in average climate conditions	**EP 5C** Observations, experiments, and theory refine computer models	**EP 6C** Human activities have altered global climate patterns	**EP 7C** Extreme Weather events are projected to increase	**GP C** Climate change affects global/national security
EP 1D Orbital Cycles	**EP 2D** Biogeochemical/ Carbon cycles	**EP 3D** Past 10,000 years have been unusual	**EP 4D** Changes in climate is normal but varies over time/space	**EP 5D** Our understanding of climate and weather differ	**EP 6D** Changes in physical and biological systems linked to human caused climate change	**EP 7D** Ocean becoming more acidic impacting marine species	**GP D** Humans may be able to mitigate climate change
EP 1E Solar Variability	**EP 2E** Particulates' impact climate	**EP 3E** Life can influence global climate	**EP 4E** Observations show temperatures have increased over past 50 yrs.	**EP 5E** Climate change projections help with potential decisions and actions	**EP 6E** Negative impacts are likely to outweigh positive impacts	**EP 7F** Ecosystems are disturbed by climate change	**GP E** Strategies needed to reduce greenhouse gases
	EP 2F Feedback systems		**EP 4F** Evidence that humans have a role in climate change			**EP 7F** Human health will be affected by climate change	**GP F** Strategies need to adaptation to climate change
			EP 4G Natural removal of carbon dioxide from the atmosphere is slow				**GP G** Actions taken at all levels of society can mitigate climate change and increase preparedness
EP 1 Uncategorized	**EP 2** Uncategorized	**EP 3** Uncategorized	**EP 4** Uncategorized	**EP 5** Uncategorized	**EP 6** Uncategorized	**EP 7** Uncategorized	**GP** Uncategorized

Figure 1. The domain of environmental literacy – EarthLabs: Climate, Weather & Biosphere



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

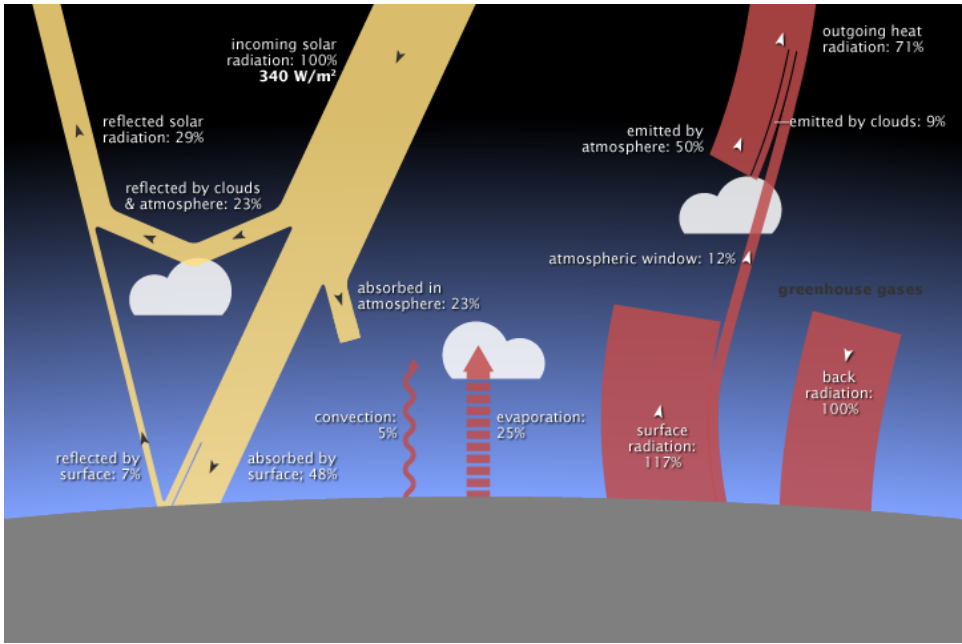
Addresses EP3A and EP3C, & 3 ELC Compenencies

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 EP1B & 3 ELC Compenencies



Mapping DRK-12 Projects to Climate & Environmental Literacy Principles

High-Adventure Science

Amy Pallant & Chad Dorsey
The Concord Consortium

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

EP 1: The sun is the primary source of energy for Earth's climate system	EP 2***: Climate is regulated by complex interactions among components of the Earth system	EP3: Life on Earth Depends on, is shaped by, and affects climate	EP4: Climate varies over space and time through both natural and man-made processes.	EP 5: Our understanding of the climate system is improved through observations, theoretical studies and modeling	EP 6: Human activities are impacting the climate system	EP 7: Climate change will have consequences for the Earth system and human lives	Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts
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EP 1B Earth energy balance	**EP 2B** Hydrosphere, energy and climate	**EP 3B** Heat-trapping gases warm Earth's surface	**EP 4B** Climate is not the same as weather	**EP 5B** Observations are key to understanding climate	**EP 6B** Burning fossil fuels increases the greenhouse gases in the atmosphere	**EP 7B** Changing climate alters freshwater resources	**GP B** Integrating climate knowledge
EP 1C Reasons for the seasons	**EP 2C** Greenhouse gases trap outgoing IR heat	**EP 3C** Changes in climate affect ecosystems and species	**EP 4C** Climate change is a change in average climate conditions	**EP 5C** Observations, experiments, and theory refine computer models	**EP 6C** Human activities have altered global climate patterns	**EP 7C** Extreme Weather events are projected to increase	**GP C** Security of nations
EP 1D Orbital Cycles	**EP 2D** Biogeochemical/ Carbon cycles	**EP 3D** Past 10,000 years have been unusual	**EP 4D** Average temperatures have increased in the past 50 years	**EP 5D** Our understanding of climate and weather differ	**EP 6D** Many human systems are linked to climate change	**EP 7D** The chemistry of ocean water is becoming more acidic	**GP D** Climate change Mitigation
EP 1E Solar Variability	**EP 2E** Particulates' impact climate	**EP 3E** Life can influence global climate	**EP 4E** Natural processes do not explain rapid climate change	**EP 5E** Climate change projections help with potential decisions and actions	**EP 6E** Negative impacts are likely to outweigh positive impacts	**EP 7F** Ecosystems are disturbed by climate change	**GP E** Strategies to reduce greenhouse gases
	EP 2F Feedback systems	**EP 3F** Life can influence global climate	**EP 4F** Natural processes do not explain rapid climate change			**EP 7F** Human health will be affected by climate change	**GP F** Adaptation to climate change
			EP 4G Natural removal of carbon dioxide from the atmosphere is slow				**GP G** Action-all levels of society

EP 2: Climate is regulated by complex interactions among components of the Earth system

EP 1: The sun is the primary source of energy for Earth's climate system	EP 2***: Climate is regulated by complex interactions among components of the Earth system		EP4: Climate	EP 5: Our understanding		EP 7: Climate	Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts
EP 1 A Sunlight warms the planet	EP 2 A Interactions of Sun and Earth systems						GP A Reduce vulnerability/ Enhance resilience
EP 1B Earth energy balance	EP 2B Hydrosphere, energy and climate	EP 3B Heat-trapping gases warm Earth's surface	EP 4B Climate is not the same as weather	EP 5B Observations are key to understanding climate	EP 6B Burning fossil fuels increases the greenhouse gases in the atmosphere	EP 7B Changing climate alters freshwater resources	GP B Integrating climate knowledge
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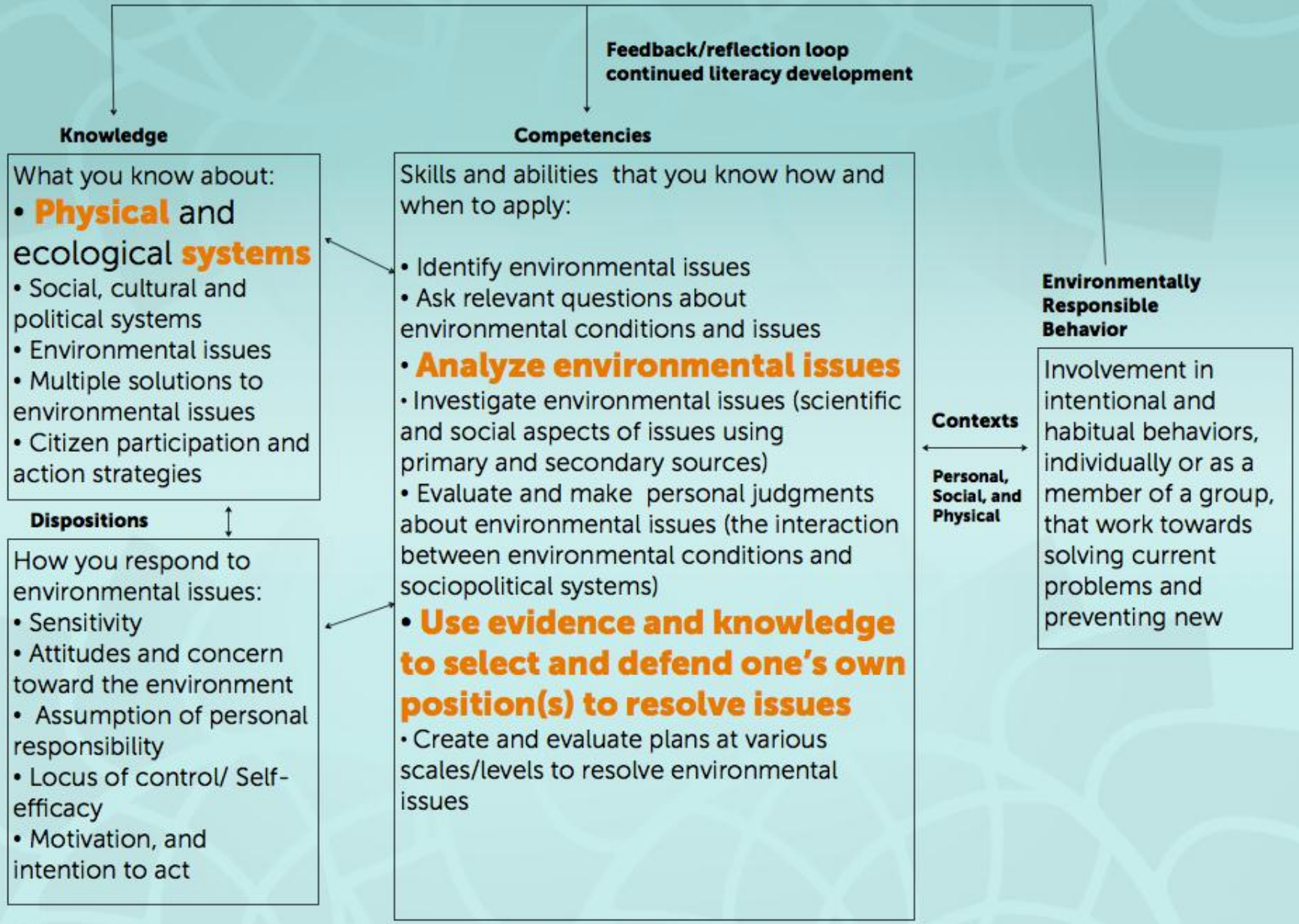
Figure 1. The domain of environmental literacy



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.

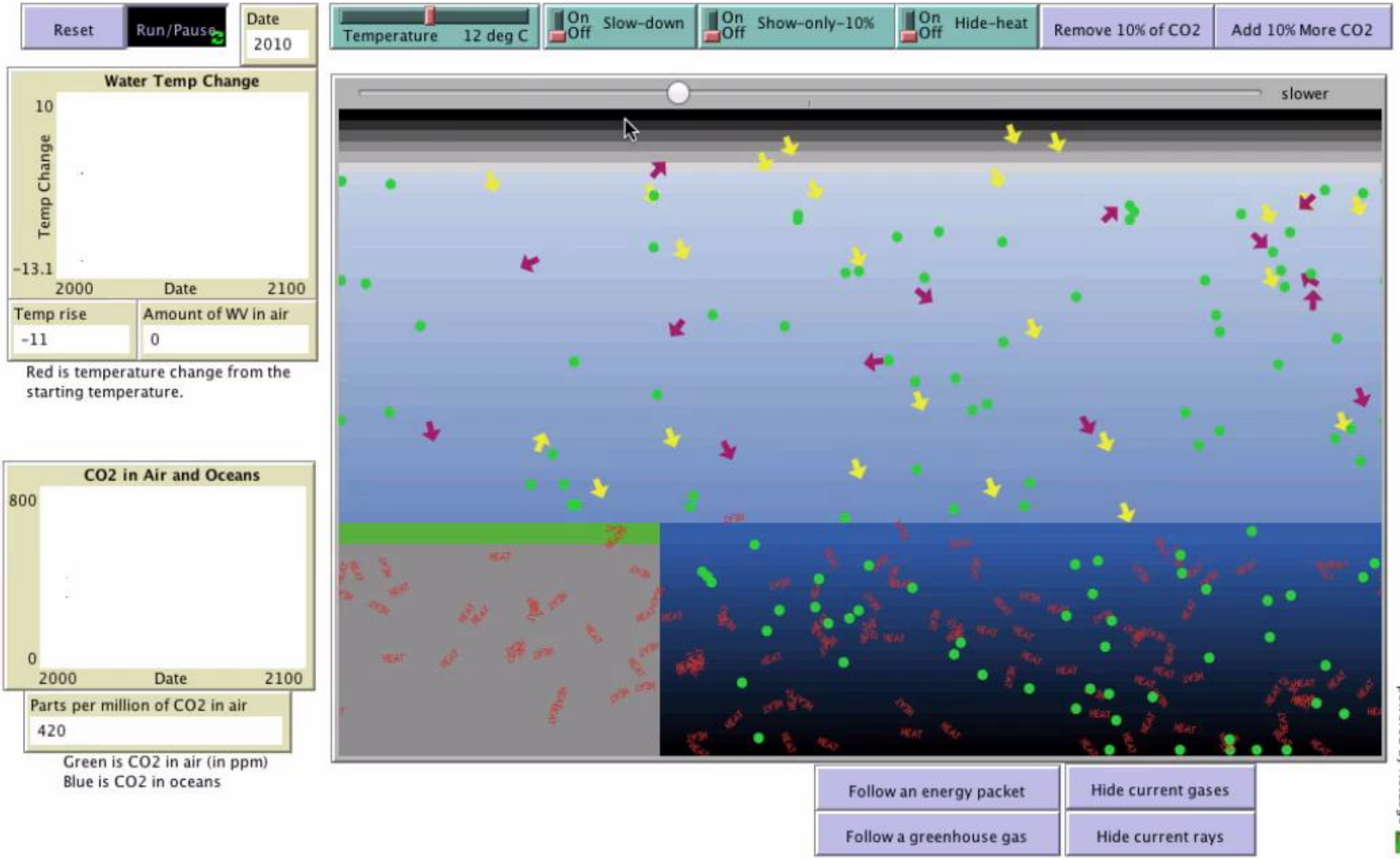
Analyze environmental issues – the interpretation and use of knowledge regarding physical, ecological & sociopolitical systems, and of information about stakeholders, their positions, beliefs and value perspectives. Also, the ability to determine relevant factors and to discern interactions among those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

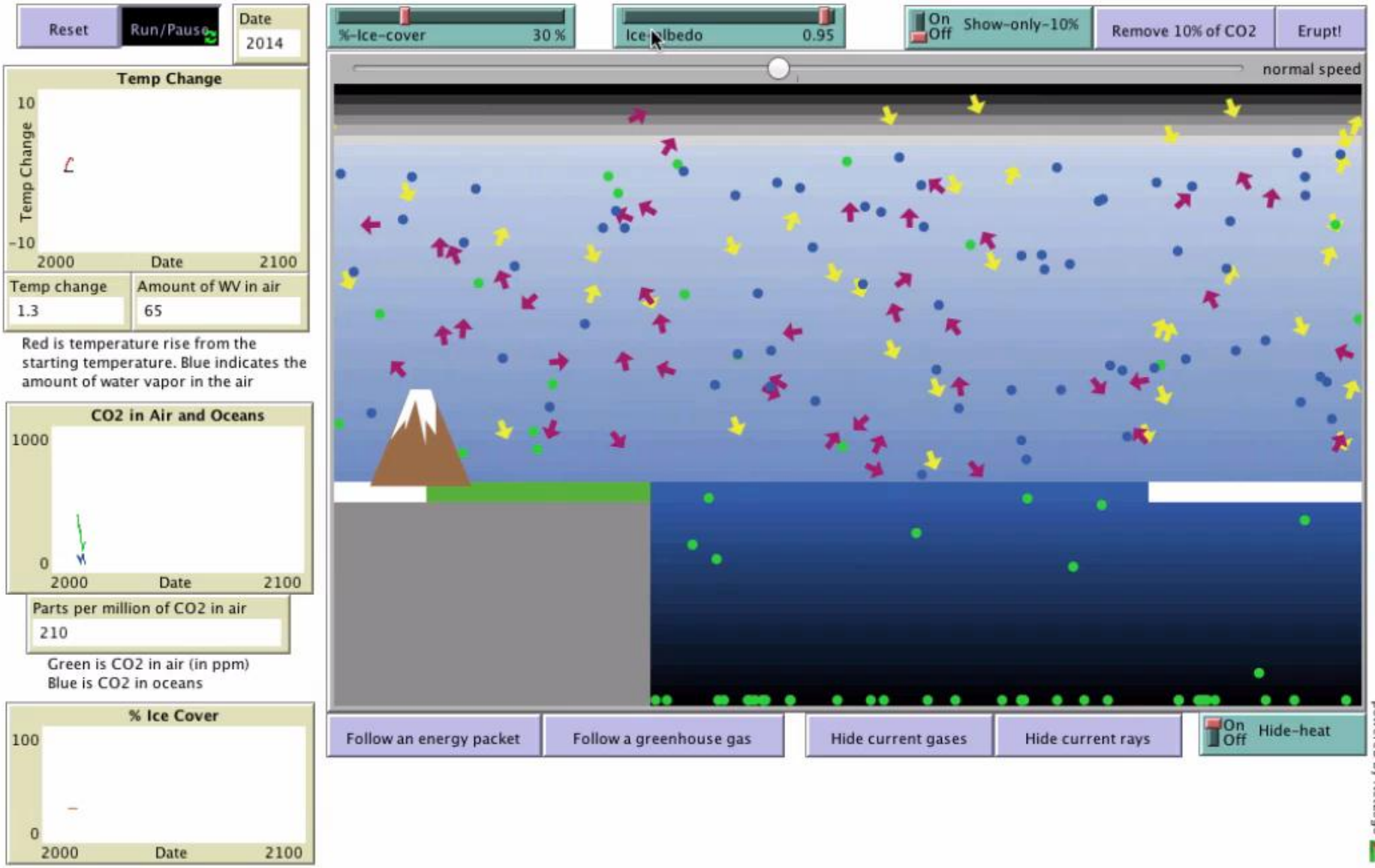
Investigate environmental issues – by gathering new information about an issue as well as locating and using relevant sources of additional information, synthesizing, and communicating the outcomes of the investigation.

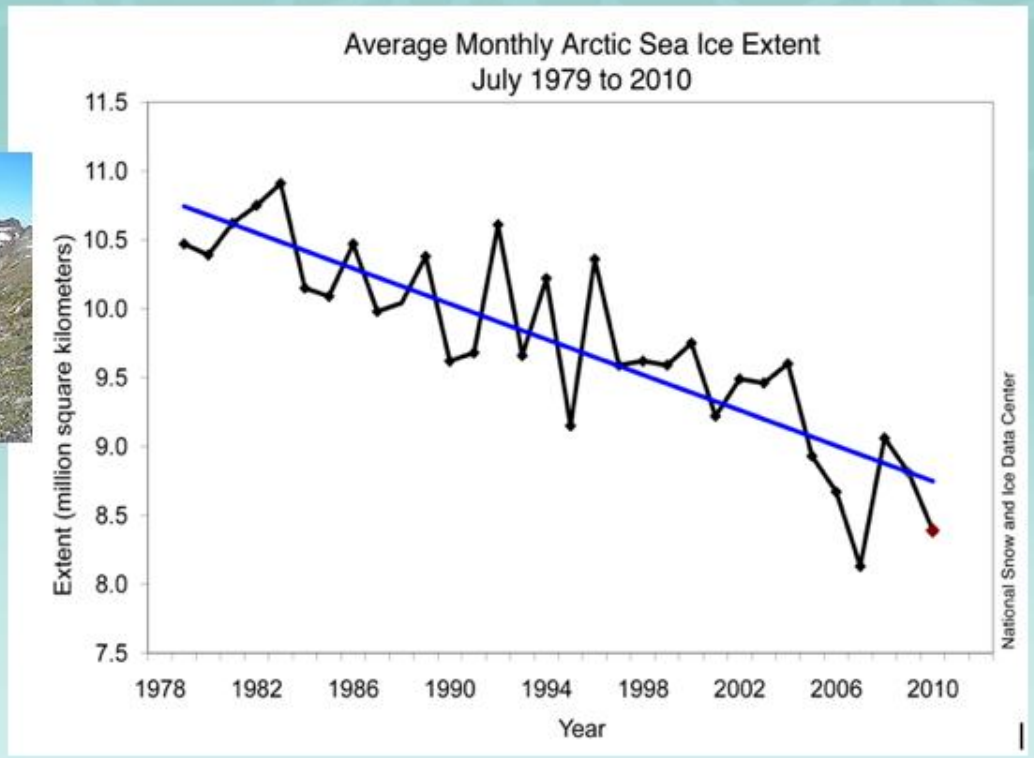
Evaluate & make personal judgments about environmental issues-- constructing dispassionate evaluations and explanations based on available information & the beliefs and values of stakeholders; and articulating views about actions that may be warranted.

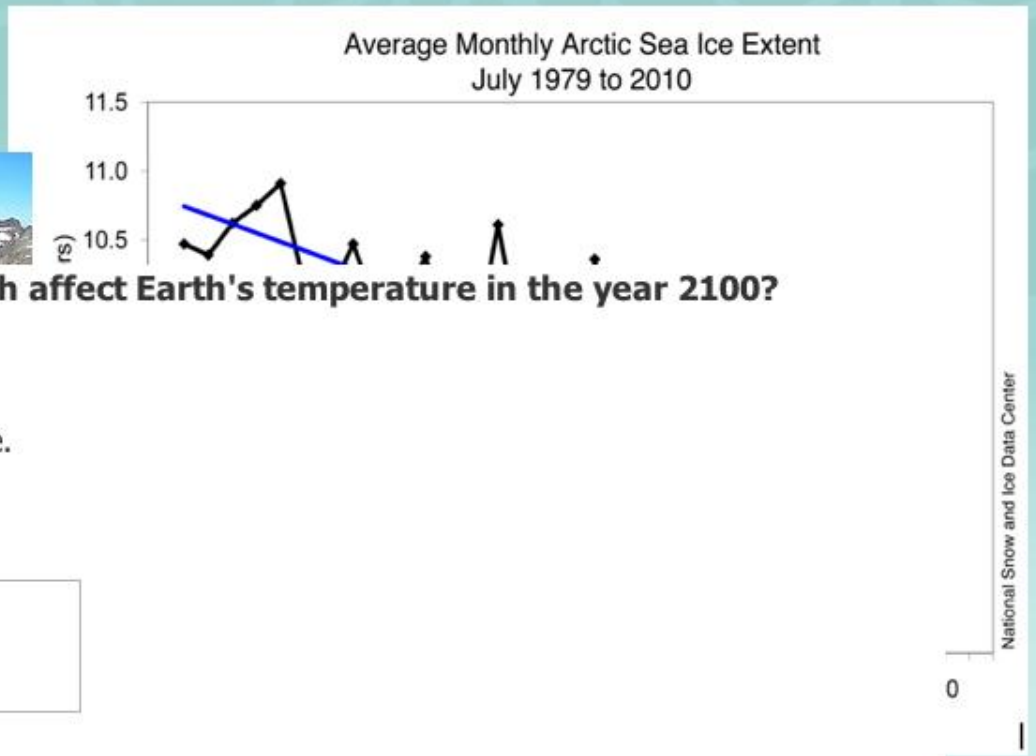
Use evidence & experience to defend positions & resolve issues – constructing and defending a sound evidence-based argument about what it will take to resolve or help resolve an issue.

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.


Reset
Run/Pause
Date
2010
Temperature
12 deg C
On
Off
Slow-down
On
Off
Show-only-10%
On
Off
Hide-heat
Remove 10% of CO2
Add 10% More CO2
Water Temp Change
10
Temp Change
-13.1
2000
Date
2100
Temp rise
-11
Amount of WV in air
0
Red is temperature change from the starting temperature.
CO2 in Air and Oceans
800
0
2000
Date
2100
Parts per million of CO2 in air
420
Green is CO2 in air (in ppm)
Blue is CO2 in oceans
slower
Follow an energy packet
Hide current gases
Follow a greenhouse gas
Hide current rays
powered by NetLogo


Reset
Run/Pause
Date
2014
%-Ice-cover
30 %
Ice-albedo
0.95
On
Off
Show-only-10%
Remove 10% of CO2
Erupt!
normal speed
Temp Change
10
Temp Change
-10
2000
Date
2100
Temp change
1.3
Amount of WV in air
65
Red is temperature rise from the starting temperature. Blue indicates the amount of water vapor in the air
CO2 in Air and Oceans
1000
0
2000
Date
2100
Parts per million of CO2 in air
210
Green is CO2 in air (in ppm)
Blue is CO2 in oceans
% Ice Cover
100
0
2000
Date
2100
Follow an energy packet
Follow a greenhouse gas
Hide current gases
Hide current rays
On
Off
Hide-heat
powered by NetLogo


Average Monthly Arctic Sea Ice Extent
July 1979 to 2010
Extent (million square kilometers)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
1978
1982
1986
1990
1994
1998
2002
2006
2010
Year
National Snow and Ice Data Center



How might the trend shown in the graph affect Earth's temperature in the year 2100?

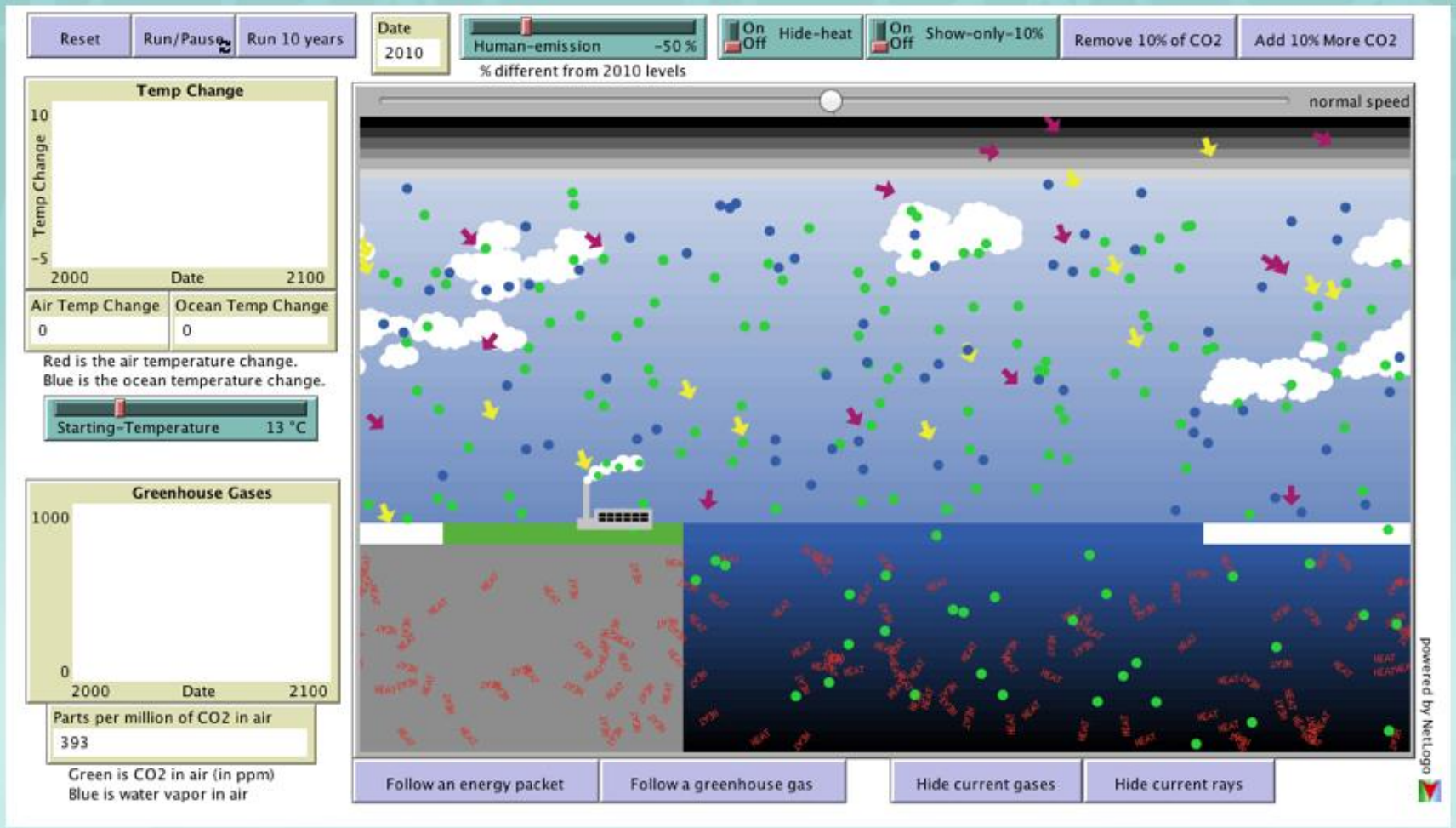
- It will increase the temperature.
- It will decrease the temperature.
- There will be no effect on the temperature.

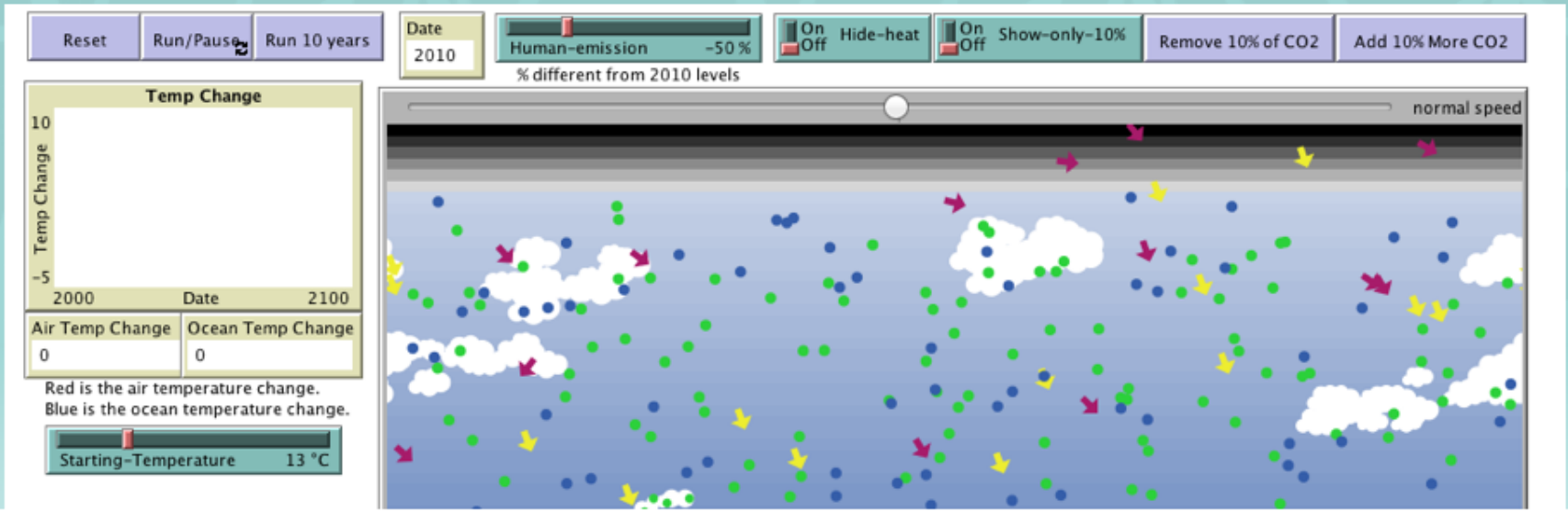
Explain your prediction.

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.


Reset
Run/Pause
Run 10 years
Date
2010
Human-emission
-50 %
% different from 2010 levels
On
Off
Hide-heat
On
Off
Show-only-10%
Remove 10% of CO2
Add 10% More CO2
normal speed
Temp Change
10
Temp Change
-5
2000
Date
2100
Air Temp Change
0
Ocean Temp Change
0
Red is the air temperature change.
Blue is the ocean temperature change.
Starting-Temperature
13 °C
Greenhouse Gases
1000
0
2000
Date
2100
Parts per million of CO2 in air
393
Green is CO2 in air (in ppm)
Blue is water vapor in air
Follow an energy packet
Follow a greenhouse gas
Hide current gases
Hide current rays
powered by NetLogo



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 CO_2 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.

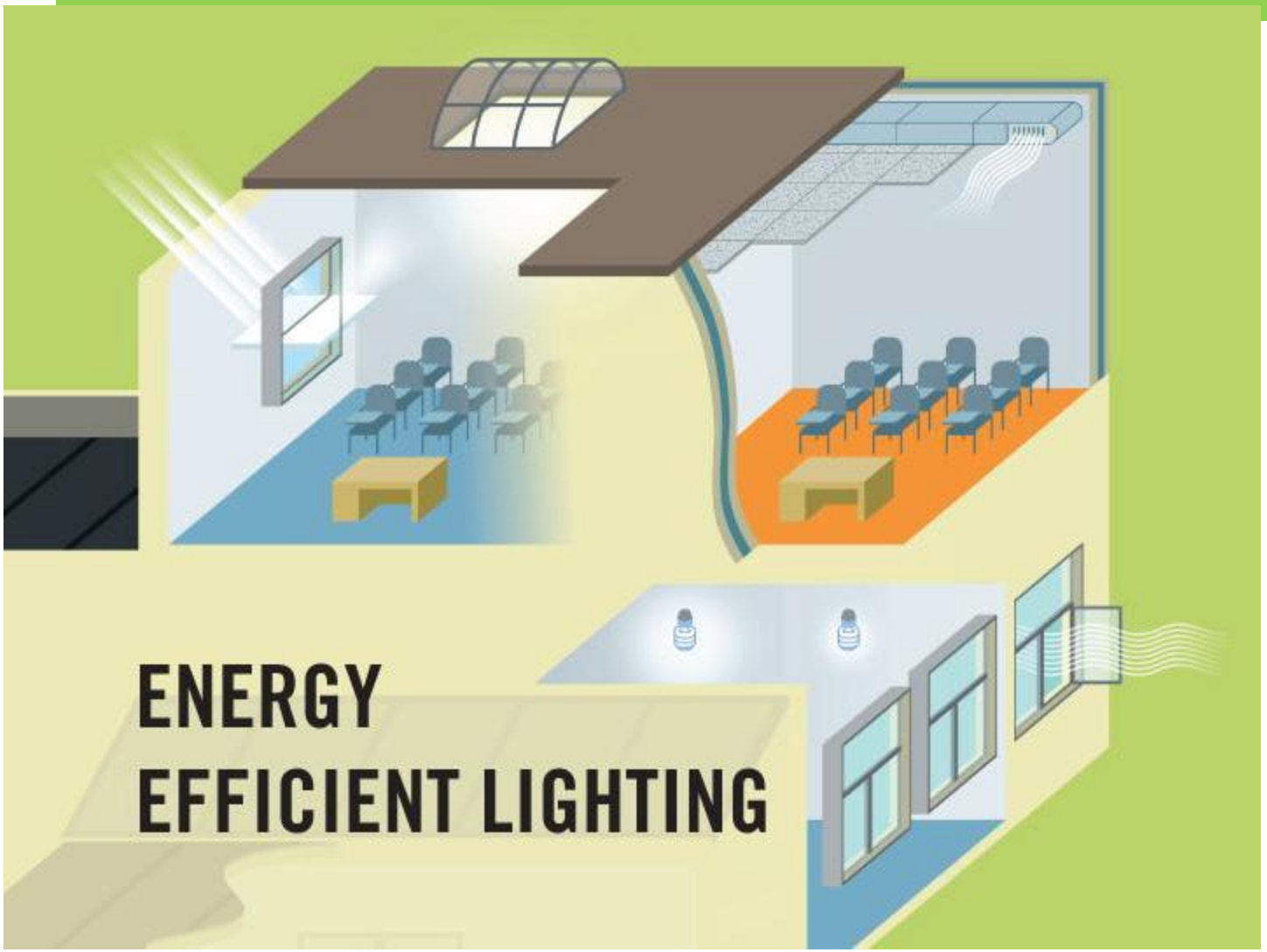
Green Schools Project

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

Prototype Unit for Grade 8



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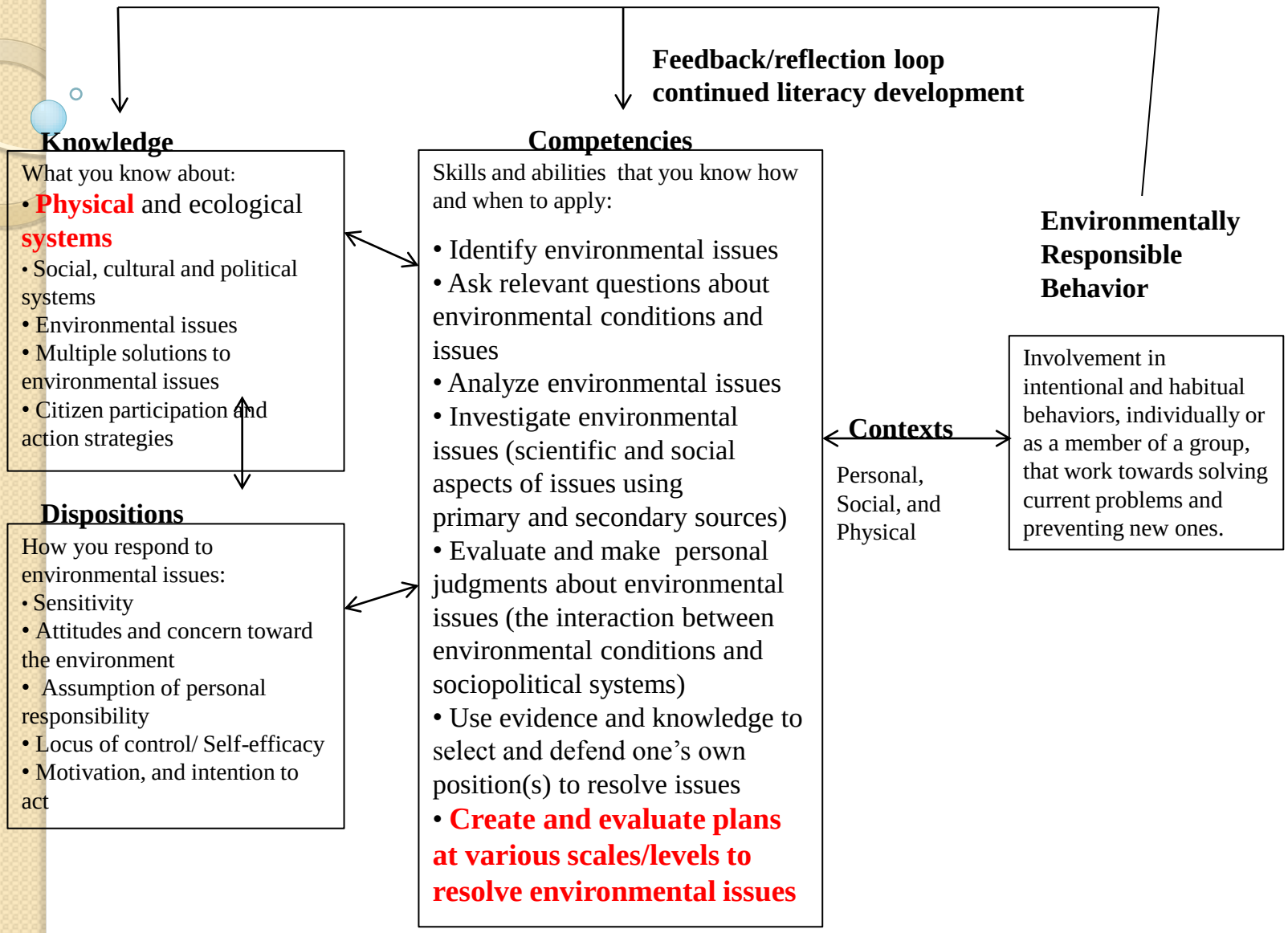

CLEP mapping

EP 1C

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

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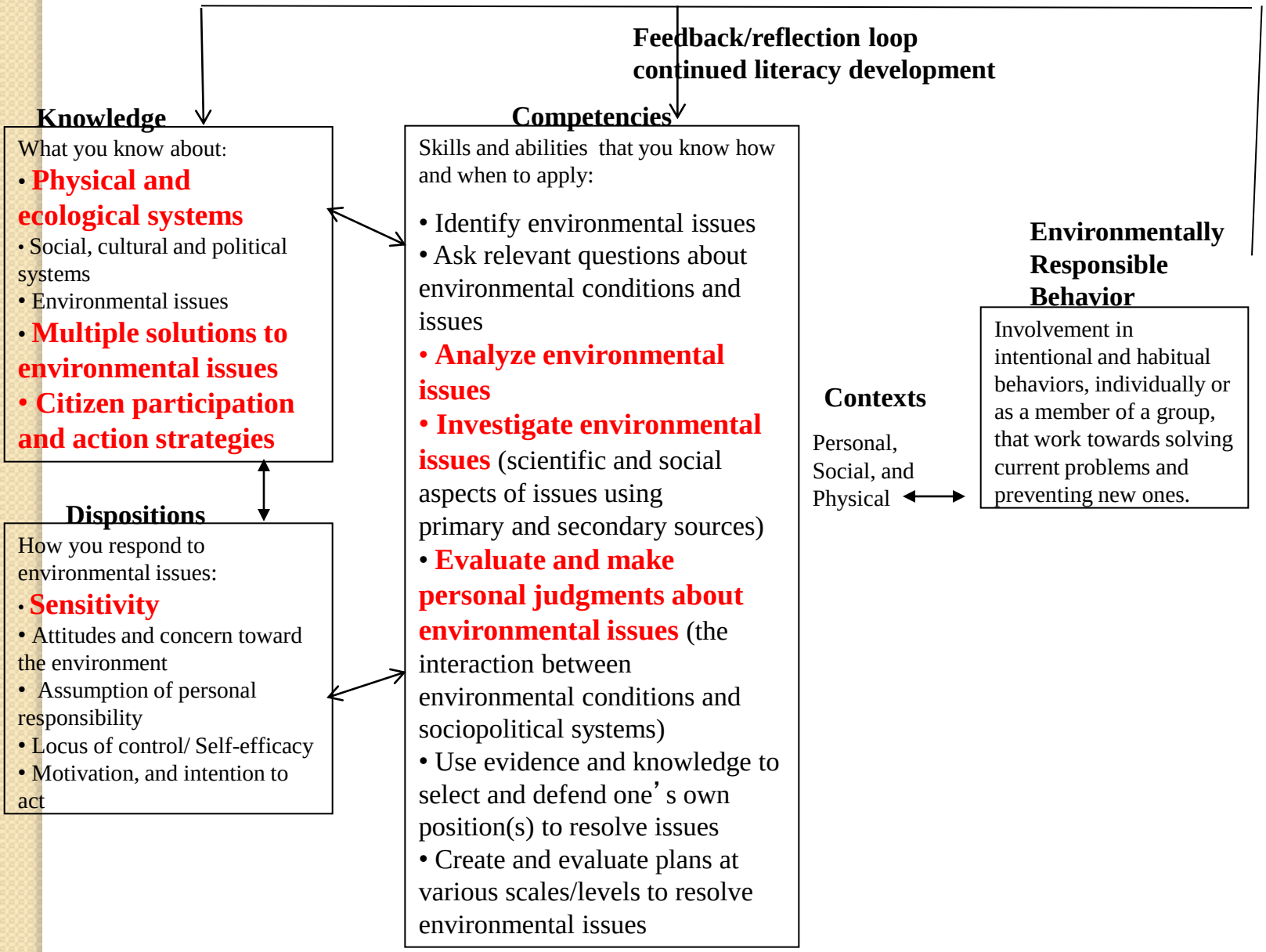

Climate Literacy Essential Principles

- **EP 2: Climate is regulated by complex interactions among components of the Earth system**
  - Hydrosphere, energy and climate
  - Feedback systems
- **EP3: 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

•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

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

Excerpt from an AP Biology teacher's adaptation and embellishment of STORE Advanced Lesson 2

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.**

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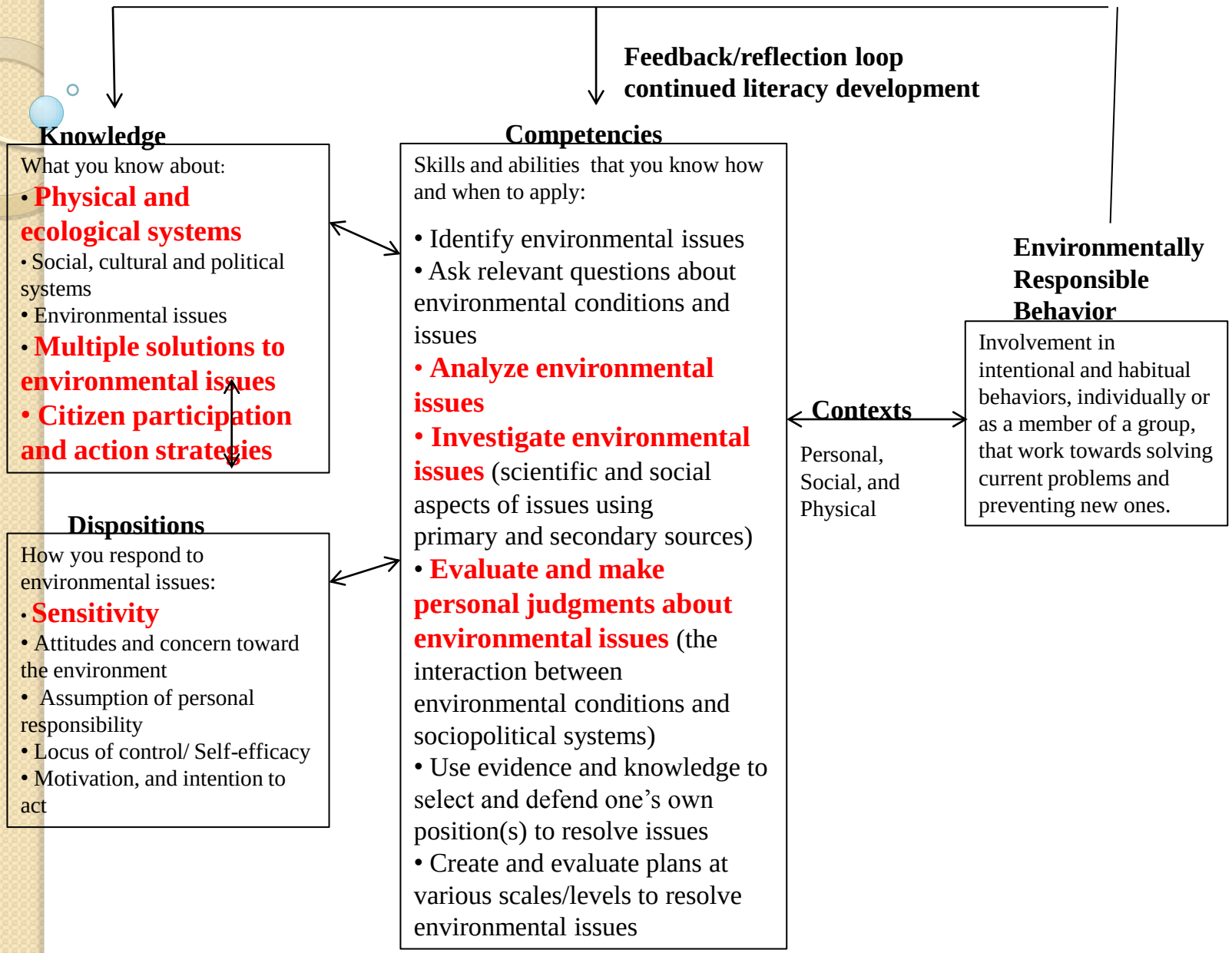
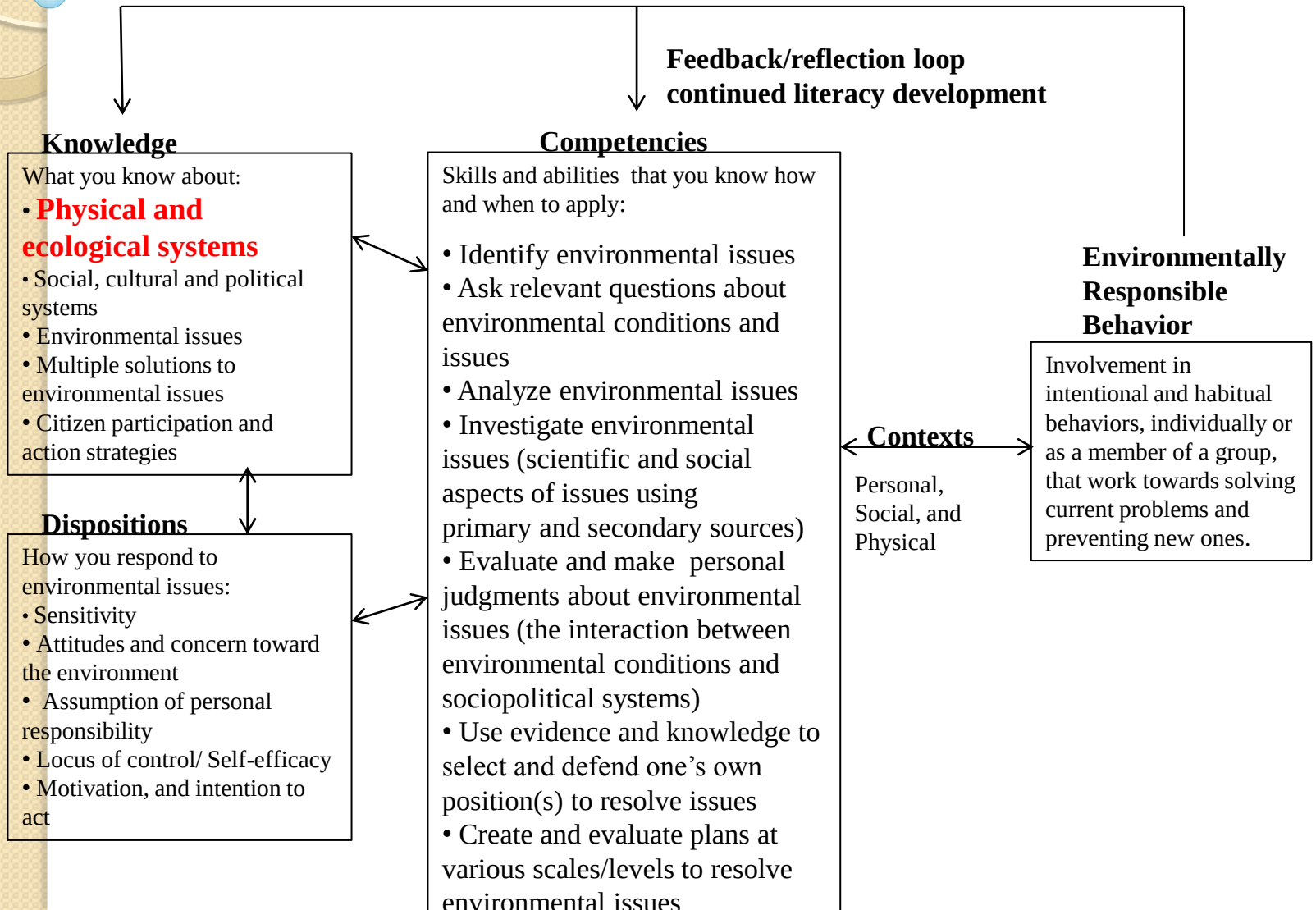


Calipers II: Using Simulations to Assess Complex Science Learning - Goals -

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



Climate Literacy: The Essential Principles of Climate Science

EP 1: The sun is the primary source of energy for Earth's climate system	EP 2: Climate is regulated by complex interactions among components of the Earth system	EP3: Life on Earth Depends on, is shaped by, and affects climate	EP4: Climate varies over space and time through both natural and man-made processes.
EP 1 A Sunlight warms the planet	EP 2 A Interactions of Sun and Earth systems	EP 3A Organisms adapt, migrate or perish	EP 4A Climate is long term
EP 1B Earth energy balance	EP 2B Hydrosphere, energy and climate	EP 3B Heat-trapping gases warm Earth's surface	EP 4B Climate is not the same as weather
EP 1C Reasons for the seasons	EP 2C Greenhouse gases trap outgoing IR heat	EP 3C Changes in climate affect ecosystems and species	EP 4C Climate change is a change in average climate conditions

Calipers II: Climate
- System Model Levels -

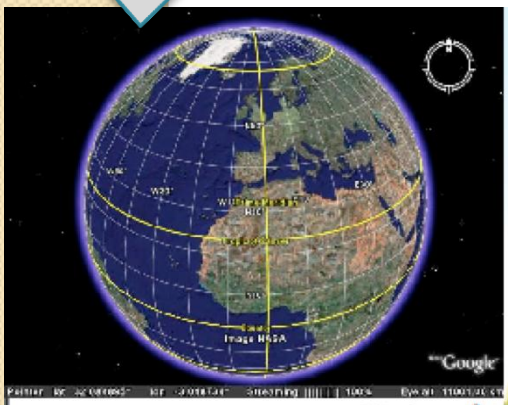
	Target Label (for the LMS)	Features	Principles	Elements Tagging Level + Clarification
Components	**1. Earth System** *Refers to the components of the system that participate in the interactions that produce the emergent phenomena.*	Energy	The Sun provides the vast majority of energy to the Earth.	**1.1 Solar Energy**
		Earth	Earth has a hydrosphere, an atmosphere, and a lithosphere.	**1.2 Hydrosphere**
				1.3 Atmosphere
				1.4 Lithosphere
Interactions	**2. Energy Flows** *Refers to the interaction of components*	Differential Heating	Differences in the surface materials, greenhouse gas concentrations and amounts of insolation produce differential heating at different latitudes and times of year.	**2.1 Variable Incoming Solar Energy**
				2.2 Absorption/Reflection/Radiation
				2.3 Greenhouse Effect
Emergent Phenomena	**3. Climate** *Refers to phenomena that emerge from the interactions of components*	Regional Climates	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.	**3.1 Regional Climate Definition**
				3.2 Factors Affecting Regional Climate
				3.3 Regional Climate Patterns
		Global Climate		**3.4 Global Climate**

Multiple Modes of Representation - Active Inquiry -

Earth View

Horizon View

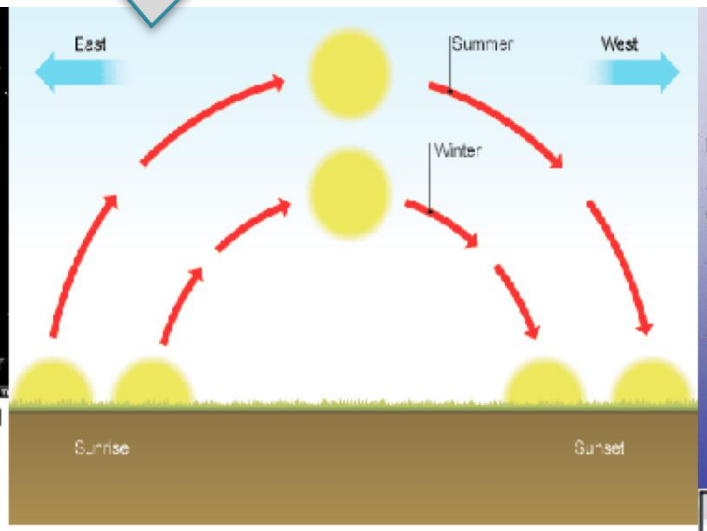
Graph shows incoming solar energy over course of a day

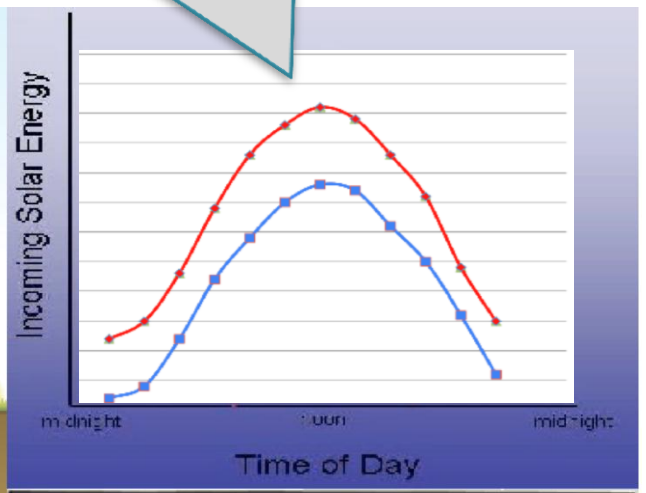


Latitude: 30°N

Jan 1	Feb 1	Mar 1	Apr 1
May 1	Jun 1	Jul 1	Aug 1
Sept 1	Oct 1	Nov 1	Dec 1

Month: Feb





Latitude	Date	Hrs of Sun	Max Sun Elevation	Total Solar

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?

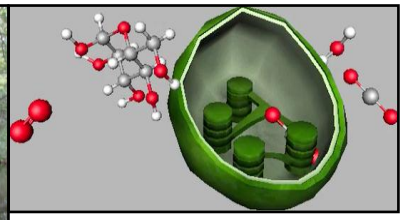
- Builds on concepts from CAREER: Causal Learning in the Classroom (NSF#0845632 to Grotzer) and earlier work.
- Includes EcoMUVE (IES#R305A080514 to Dede and Grotzer)
- Adds Augmented Reality (AR) as an immersive interface utilizing mobile, context-aware technologies and software that enables participants to interact with digital information embedded within the physical environment and to build on the MUVE.

Action at a Distance

Change over Time

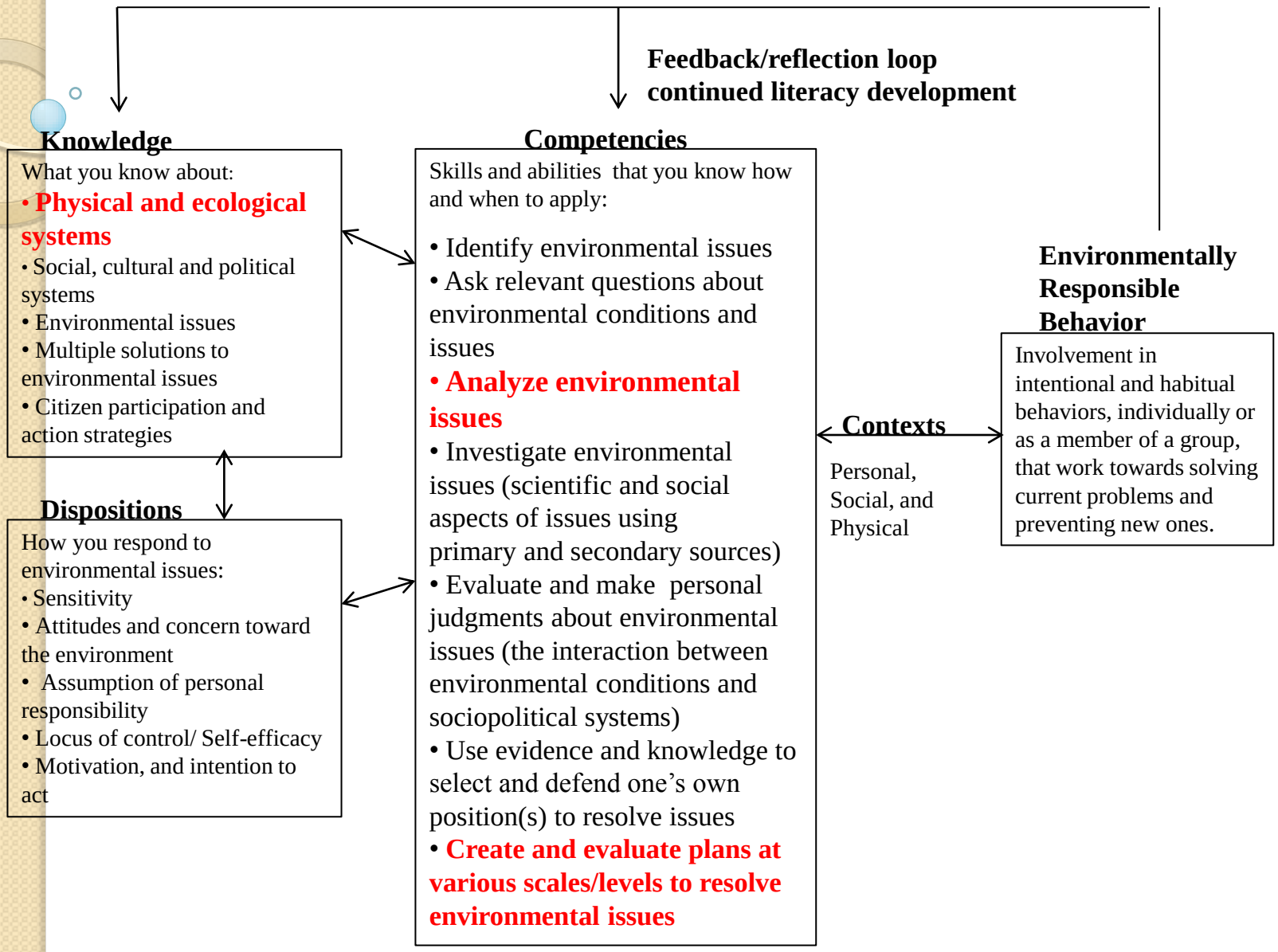
Non-obvious Causes

Seeing the Unseen



A student using a visual target to see a 3-D image on the smartphone.

Figure 1. The domain of environmental literacy



Climate Literacy: The Essential Principles of Climate Science

EP 1: The sun is the primary source of energy for Earth's climate system	EP 2: Climate is regulated by complex interactions among components of the Earth system	EP3: Life on Earth Depends on, is shaped by, and affects climate	EP4: Climate varies over space and time through both natural and man-made processes.	EP 5: Our understanding of the climate system is improved through observations, theoretical studies and modeling	EP 6: Human activities are impacting the climate system	EP 7: Climate change will have consequences for the Earth system and human lives	Guiding Principle for informed climate decision: Humans can take actions to reduce climate change and its impacts
EP 1 A Sunlight warms the planet	EP 2 A Interactions of Sun and Earth systems	EP 3A Organisms adapt, migrate or perish	EP 4A Climate is long term	EP 5A Earth's climate system is subject to physical laws of the universe	EP 6A Humans likely caused global temperature increases	EP 7A Thermal expansion is causing sea level rise	GP A Reduce vulnerability/ Enhance resilience
EP 1B Earth energy balance	EP 2B Hydrosphere, energy and climate	EP 3B Heat-trapping gases warm Earth's surface	EP 4B Climate is not the same as weather	EP 5B Observations are key to understanding climate	EP 6B Burning fossil fuels increases the greenhouse gases in the atmosphere	EP 7B Changing climate alters freshwater resources	GP B Integrating climate knowledge
EP 1C Reasons for the seasons	EP 2C Greenhouse gases trap outgoing IR heat	EP 3C Changes in climate affect ecosystems and species	EP 4C Climate change is a change in average climate conditions	EP 5C Observations, experiments, and theory refine computer models	EP 6C Human activities have altered global climate patterns	EP 7C Extreme Weather events are projected to increase	GP C Security of nations
EP 1D Orbital Cycles	EP 2D Biogeochemical/ Carbon cycles	EP 3D Past 10,000 years have been unusual	EP 4D Average temperatures have increased in the past 50 years	EP 5D Our understanding of climate and weather differ	EP 6D Many human systems are linked to climate change	EP 7D The chemistry of ocean water is becoming more acidic	GP D Climate change Mitigation
EP 1E Solar Variability	EP 2E Particulates' impact climate	EP 3E Life can influence global climate	EP 4E Natural processes do not explain rapid climate change	EP 5E Climate change projections help with potential decisions and actions	EP 6E Negative impacts are likely to outweigh positive impacts	EP 7F Ecosystems are disturbed by climate change	GP E Strategies to reduce greenhouse gases
	EP 2F Feedback systems	EP 3F Life can influence global climate	EP 4F Natural processes do not explain rapid climate change			EP 7F Human health will be affected by climate change	GP F Adaptation to climate change
			EP 4G Natural removal of carbon dioxide from the atmosphere is slow				GP G Action-all levels of society
EP 1 Uncategorized	EP 2 Uncategorized	EP 3 Uncategorized	EP 4 Uncategorized	EP 5 Uncategorized	EP 6 Uncategorized	EP 7 Uncategorized	GP Uncategorized

Acknowledgments

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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
  - CLEAN Community http://cleanet.org/clean/community/
  - Tri-agency Climate Change Education community https://nice.larc.nasa.gov/tri_pi/
  - Can we interact with/join these communities?