FLINNSTEM™

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IMSA Fusion — Climate Change STEM Curriculum Module

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Curriculum Overview

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Climate Change: The Future is Now engages participants in a variety of investigations to help establish basic understandings regarding climate science literacy. Exploration through both virtual and real-time experiments, the use of web based applications, modeling and engineering experiences will help participants identify the facts, issues, and actions they wish to take.

Curriculum Objectives

The students will learn:

- humans can take actions to reduce climate change and its impacts
- humans can adapt to climate change by reducing their vulnerability to its impacts
- the abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between their ocean, land, live and atmosphere reservoirs
- our understanding of the climate system is improved through observations, theoretical studies, and modeling
- emissions from widespread burning of fossil fuels since the start of the Industrial Revolution have increased the concentration of greenhouse gases in the atmosphere
- human activities have affected the lands, oceans, and atmosphere, and the changes have altered global climate patterns
- melting ice sheets and glaciers, combined with the thermal expansions of seawater as the oceans warm is causing sea level rise
- the chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere
- ecosystems on land and in the ocean have been and will continue to be disturbed by climate change

Logistics

Class age/size:	All lessons are designed for twenty 4th-5th grade students.
Materials:	See insert for each individual activity within this curriculum.
Time:	This curriculum is designed for 32 content hours. See individual activities for suggested times.
Location:	All activities may be taught in a classroom. Water is needed for some activities.

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Standards and Practices

NOAA Climate Literacy Essential Principles

NOAA 1: Humans can take actions to reduce climate change and its impacts
NOAA 2: Humans can adapt to climate change by reducing their vulnerability to its impacts
NOAA 3: The abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between their ocean, land, live and atmosphere reservoirs
NOAA 4: Our understanding of the climate system is improved through observations, theoretical studies, and modeling
NOAA 5: Emissions from widespread burning of fossil fuels since the start of the Industrial Revolution have increased the concentration of greenhouse gases in the atmosphere
NOAA 6: Human activities have affected the lands, oceans, and atmosphere, and the changes have altered global climate patterns
NOAA 7: Melting ice sheets and glaciers, combined with the thermal expansions of seawater as the oceans warm is causing sea level rise
NOAA 8: The chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere
NOAA 9: Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change

References to NOAA Climate Literacy The Essential Principles of Climate Science, http://cpo.noaa.gov/sites/cpo/Documents/pdf/ClimateLiteracyPoster-8_5x11_Final4-11.pdf

NGSS Scientific and Engineering Practices

1. Asking questions and defining problems (SEP1)
2. Developing and using models (SEP2)
3. Planning and carrying out investigations (SEP3
4. Analyzing and interpreting data (SEP4)
5. Using mathematics and computational thinking (SEP5)
6. Constructing explanations and designing solutions (SEP6)
7. Engaging in argument from evidence (SEP7)
8. Obtaining, evaluating, and communicating information (SEP8)

Next Generation Science Standards

4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.
4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment.
4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.
4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
5-ESS2-1: Develop a model using an example to describe ways in which the geosphere biosphere, hydrosphere, and/or atmosphere interact.

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5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water.
5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
5-PSI-2: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
MS-ESS3-3: apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4: construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
MS-LS1-2: Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.
MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting sub-systems composed of groups of cells.
MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2: construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem.
MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles

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and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

References to Next Generation Science Standards are adapted from NGSS. NGSS is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Common Core State Standards Mathematical Practices
MP1: Make sense of problems and persevere in solving them.
MP2: Reason abstractly and quantitatively.
MP3: Construct viable arguments and critique the reasoning of others.
MP4: Model with mathematics.
MP5: Use appropriate tools strategically.
MP7: Look for and make use of structure.

Common Core State Standards Mathematics
3.MD.A.1 : Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram.
3.MD.A2: Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[1] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[2]
3.MD.B.3: Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. *For example, draw a bar graph in which each square in the bar graph might represent 5 pets*.
3.MD.B.4: Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.
4.MD.A.1: Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...*
4.MD.A.2: Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.
5.G.A.1: Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on

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each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and *y*-coordinate).
5.MD.A.1: Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.
5.NBT.A.1: Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.
5.NBT.A.2: Explain patterns in the number of zeroes of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.
6.EE.A1: Write and evaluate numerical expressions involving whole-number exponents.
6.EE.C.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.
6.EE.A.2.c: Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations). *For example, use the formulas* $V = s^3$ *and* $A = 6\ s^2$ *to find the volume and surface area of a cube with sides of length s = 1/2*.
6.NS.C.5: Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.
6.RP.A.2: Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship. *For example, "This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is 3/4 cup of flour for each cup of sugar." "We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger."*[1]
6.RP.A.3.c: Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.
8.SP.A.1: Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

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Common Core State Standards English Language Arts

RI.4.3: Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
RI.4.5: Describe the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in a text or part of a text.
RI.4.7: Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.
RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6–8 texts and topics*.
RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
SL.4.2: Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
SL.4.4: Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
SL.4.5: Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.
SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.
SL8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
W4.1: Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
W4.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
W4.7: Conduct short research projects that build knowledge through investigation of different aspects of a topic
W4.9: Draw evidence from literary or informational texts to support analysis, reflection, and research.
W.5.1: Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
W.5.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
W.5.7: Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

W.5.9: Draw evidence from literary or informational texts to support analysis, reflection, and research.
WHST.6-8.1: Write arguments focused on *discipline-specific content*.
WHST.6-8.9: Draw evidence from informational texts to support analysis reflection, and research.

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Unit Summaries and Objectives

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It's the L. A. W.

In the first lesson, "**It's the L. A. W.,"** students begin thinking about how they use the **L**and, **A**ir, and **W**ater for different activities in which they participate, as well as what resources each of these provides. They also begin to visualize the Earth as a system.

The students will:

- share their ideas about uses of land, air, and water
- explain how the land, air, and water are linked
- hypothesize how global warming may be affecting land, air, and water
- work collaboratively to develop a flow chart

Where Next?

As a major greenhouse gas, carbon travels naturally in a cycle. Humans have accelerated the amount of carbon emitted into the atmosphere. Through the use of a game to begin the lesson **"Where Next?"**, the students then develop a model to explore the carbon cycle.

The students will:

- describe and draw a model of the carbon cycle
- identify events that impact the carbon cycle
- classify the impact of an event as harmful or helpful to the environment
- evaluate events impacting the carbon cycle as natural or human in origin

The Greenhouse Effect

How certain gases in the atmosphere contribute to global warming is often explained by simple analogy with greenhouses or sealed automobiles on a hot day. Students will go one step deeper by constructing a physical model of the Earth's atmosphere to simulate how it interacts with light. They will collect data and analyze the effect of increasing greenhouse gases.

Footprints on the Earth

Carbon dioxide quantities contributed to the atmosphere vary based on our activities. This amount can be calculated using a computer program. In the lesson **"Footprints on the Earth"** each student will determine the size of their carbon footprint, examine the reasons, and develop strategies for a carbon footprint.
The students will:

- use an online program to determine their carbon footprint
- read and interpret data
- plan methods for lessening their carbon footprint
- calculate carbon emissions

Designer Bags

Plastic is petroleum based. Netted produce bags are often made from polyethylene. In the lesson **"Designer Bags,"** a local group asks the FUSION team to help solve the problem of

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too many polyethylene bags lying around their agricultural based community. This simulation engages the student in authentic problem solving.

The students will:

- define a solution to a problem based on materials and time
- develop a plan for scaling up production of a product
- evaluate trade-offs of product development

Lost Land

The lesson **"Lost Land"** familiarizes the students with the Dust Bowl, the current cost of soil erosion both financially and environmentally, as well as the need to preserve soil. Using stream tables, participants examine the effects of water erosion on agricultural soil. The students will:

- discuss facts about the Dust Bowl
- investigate the effects of water erosion and deposition
- participate in a simulation of erosion and deposition
- engineer a method to reduce erosion on a simulated farm field

A Day at the Beach

"A Day at the Beach" is a multi-part activity. Students develop a knowledge base about pH and ocean acidification. Next, they take this information to predict and test the effects of acidification on various shells of marine organisms.

The students will:

- explore acidity and pH
- develop an understanding of ocean acidification
- observe effects of ocean acidification on various shells of marine organisms

Coral Reefs

Coral reefs represent a unique ecosystem which is particularly vulnerable to climate change. Students will learn a bit about the biology of coral and then conduct a simulation to observe the many ways which a changing climate can impact the reef ecosystem.

Tracking the Storm

In the lesson **"Tracking the Storm"** biographies of hurricanes will be read and shared to gain background information and familiarity. Using a NOAA Atlantic hurricane tracking chart, students will chart the tracks of some hurricanes. Next they will examine the data to help draw conclusions about the formation and paths of hurricanes.

The students will:

- classify storms as hurricanes or cyclones
- convert miles per hour to knots
- graph paths of hurricanes and other related data
- read, summarize, and communicate historical information regarding hurricanes

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The Past, The Present, and The Future

Generating graphs, examining coastal population patterns, and reviewing data from NOAA regarding hurricanes over the past two centuries are among the activities in the lesson **"The Past, The Present, and The Future."** The students will consider the impact of human changes in these areas and the potential impact of climate change on hurricanes in the future.

The students will:

- graph historical data on frequency of hurricanes and coastal population growth
- analyze, interpret, summarize, and draw conclusions from data in various formats
- discuss technologies used in modeling hurricane tracking and prediction
- determine factors involved in determining cost of destruction of hurricanes
- draw conclusions on the impact of climate change on the future of hurricanes

Season Creep

As global temperatures increase, spring-like days come ever earlier on the calendar. Organisms must adjust to this change. Curiously, they adjust at different rates. This is problematic to any pair or group of organisms that rely on synchronizing their life cycles. Students will simulate an ecosystem composed of two species of flower and two species of pollinating hummingbirds. As their flowering and feeding cycles drift apart, students will collect and analyze data to determine which species is at greatest risk.

Raging Waters (I'm Melting, Your Coastal Kingdom, The Damage Done)

There are many consequences of the continual rise of the sea level. Through three activities in the lesson **"Raging Waters,"** students discover some of these consequences. *I'm Melting* engages the students in accessing satellite images of polar ice from which to collect data and draw conclusions. They will test some ideas about melting ice by designing and conducting an experiment. *Your Coastal Kingdom* puts students in charge of planning how a coastal community will adapt to rising sea levels. In *The Damage Done*, students use an interactive map to select a United States coastal city. They then manipulate the amount of sea level rise and are able to visualize the effects on that community.

The students will:

- examine the causes of sea level rising
- model sea level rising
- plan for adapting to rising sea levels
- simulate the effects of sea level rising on the United States

Let's Go Shopping

Textile recycling is less prevalent than other types of recycling. Students will follow the life cycle of a textile product in the lesson **"Let's Go Shopping"**. Then they will make a reusable shopping bag from an old t-shirt.

The students will:

- follow the life cycle of a piece of clothing
- construct a reusable bag

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Storybook Solutions

Students read a story about a group of forest animals that go in search of a solution to global warming. After critiquing the book, students create their own storybooks that show realistic solutions to problems associated with climate change.

It's Time You Know

Culmination of the unit happens in **"It's Time You Know"**, when students select a public service announcement (PSA) topic. After researching their area of interest, they make a PSA in a format of their choice to share with the school community.

The students will:

- research various aspects of climate change
- design a public service announcement

It's The L.A.W.

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Objectives

The students will:

- share their ideas about uses of land, air, and water
- explain how the land, air, and water are linked
- hypothesize how global warming may be affecting land, air, and water
- work collaboratively to develop a flow chart

Standards

SEP 2
SEP 6
SEP 8
5-ESS2-1
5-ESS3-1
SL.4.4
SL.5.1
W.5.8
GO9

Background

The atmosphere consists of layers. Moving away from the surface of the Earth, the layers are the troposphere, stratosphere, mesosphere, thermosphere, and exosphere. Energy from the sun enters the atmosphere while some of it is reflected back to space. Energy entering the atmosphere first heats up the surrounding air, eventually making its way to heat up the entirety of Earth's surface. In turn the Earth radiates some heat back into the atmosphere. Greenhouse gases in the atmosphere delay this heat energy from escaping by absorbing some of the energy and release it back toward Earth. This cycle continues as if Earth were wrapped in a never-ending blanket.

Biotic (living) and abiotic (non-living) factors are changing as a result of the global warming. Carbon dioxide, methane, and water vapor are among the main greenhouse gases that occur naturally on Earth, but humans are accelerating the rate at which they are being added to the atmosphere. Evidence of both rates and consequences of these greenhouse gases from the past are determined through the collection of proxy data. This includes looking at items such as ice core data, tree rings, and lake sediments.

Inquiry Overview

First students may respond to a survey to express what they know and how they think about the topic of climate change in an anonymous format. After that, small groups work collaboratively to brainstorm ways in which land ("L"), air ("A"), and water ("W") are valued and used. Then they explain how the three are interrelated and potentially affected by consequences of global warming.

Advanced Preparation

Decide where the first activity will be held due to the amount of space students will need to complete their group work.

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Activity

- Students work in groups of 4

Estimated Time:

- 15 Minutes: Introduction
- 60 Minutes: Brainstorming, Discussion, and Recording Ideas
- 15 Minutes: Assemble Poster
- 45 Minutes: Sharing and Discussion of Poster and Debrief

Materials

For the class:

- Masking Tape
- Markers
- *Coloring Supplies*

For each group of 4:

- 3 Sheets of poster board
- 3 Connector Pieces of poster board

Climate Change: The Future is Now involves all factors of our environment, both living (biotic) and non-living (abiotic), which includes the land, air, and water.

Students will be making a poster for each of the three in this system. Each group may pick where they would like to start. For example, they may start with land. They should put "LAND," on their poster. Now their task is to work together and brainstorm as many different ways the land is used. You may want to prompt their thinking with questions such as,

- What do we get from the land?
- How do we use the land?
- Where do we live?
- Do we get anything from the Earth?

Next, have the students record their ideas on the poster board. Remind them to write large enough so that others will be able to read what they have written.

Walk around the room while students are working. Assist them by asking them to clarify their ideas. Use prompting questions as needed.

Have groups repeat this process for the, "Air," and the, "Water."

After groups have had ample time to complete these three posters, ask them to shift their thinking. Again use a series of questions such as the ones below. Ask students to clarify their ideas within their groups.

- How are these topics related to each other?
- Does the land affect the water?
- Does the water affect the atmosphere?
- Does the atmosphere affect the water?

When you are confident that the groups have the concept that land, air, and water are interrelated show the groups a connector strip of poster board. This is where the groups will

write their ideas about how one environment affects the other. Encourage students to use arrows to show the flow of their ideas. Distribute the poster board. Assist groups as needed.

Ask students to think about how they would assemble their connector to their posters to make a flow chart. They will use MASKING TAPE. Assist as needed. Have groups share their "It's the L. A. W." flow charts.

Host a discussion using the debrief questions. They will provide insight as to where the students are in their understanding of the topic. You may also want to post the flow charts the groups produced. It will be helpful to refer back to the charts throughout the unit.

Debrief

Ask the students:

- What were the most important uses of the land?
- What were the most important uses of the atmosphere?
- What were the most important uses of the water?
- How do these systems affect each other?
- How do you think climate change might affect these systems?
- Is it important to protect these systems? Explain your ideas.

Resources

http://www.ncdc.noaa.gov/paleo/globalwarming/what.html

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