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| **Title** | **Climate Change Impacts** |
| **Introduction** | In these lessons (originally designed as a part of a larger four week unit on Energy Efficiency), students explore heat transfer and earth’s climatic change impacts over time through experimentation, data collection, discussion, research and analysis. The lessons are written for five eighty-five minute class periods in an integrated math and science course as a series of culminating activities and as an assessment of a student’s ability to engage in informational research, real-world data analysis, and communication of data significance. Therefore, you will find standards listed below for both math and science. However, if desired, a primary focus in either math or science content could be taken with only minor modifications. In their original context, these lessons were followed by a week of students writing an informational research paper regarding energy efficiency. Students received help from their English teacher about how to write an informational research paper. |
| **Curriculum Alignment** | **National Math Standards for Data Analysis**  **Formulate questions** that can be addressed with data and collect, organize, and display relevant data to answer them.   * understand the meaning of measurement data and categorical data, of bivariate data, and of the term variable; * understand scatterplots and use them to display data;   **Select and use** appropriate statistical methods to analyze data.   * for bivariate measurement data, be able to display a scatterplot, describe its shape, and determine regression coefficients, regression equations, and correlation coefficients using technological tools; * display and discuss bivariate data where at least one variable is categorical; * identify trends in bivariate data and find functions that model the data or transform the data so that they can be modeled.   **Develop and evaluate** inferences and predictions that are based on data   * evaluate published reports that are based on data by examining the design of the study, the appropriateness of the data analysis, and the validity of conclusions;   **Common Core State Standards for Math**  **Mathematical Practices**  1. Make sense of problems and persevere in solving them.  2. Reason abstractly and quantitatively.  3. Construct viable arguments and critique the reasoning of others.  4. Model with mathematics.  5. Use appropriate tools strategically.  6. Attend to precision.  7. Look for and make use of structure.  8. Look for and express regularity in repeated reasoning.  While all of the above mathematical practices are involved in this week of exploration of data, numbers 2, 4 and 5 will be emphasized.  **Common Core Math Standards**   |  |  | | --- | --- | | |  | | --- | | **S.ID.6** Summarize, represent, and interpret data on two categorical and quantitative variables  Represent data on two quantitative variables on a scatter plot, and describe their relation.   1. Fit a function to the data; use functions fitted to data to solve problems   in the context of the data. Use given function or choose a function suggested  by the context. Emphasize linear, quadratic, and exponential models.   1. Informally assess the fit of a function by plotting and analyzing residuals. |   **S.ID.8** Summarize, represent, and interpret data on two categorical and quantitative variables  Compute (using technology) and interpret the correlation coefficient of a linear fit.  **S.ID.9** Interpret linear models - Distinguish between correlation and causation.  **National Science Standards**  **Scientific and Engineering Practices**   * Asking questions (for science) and defining problems (for engineering) * Developing and using models * Analyzing and interpreting data * Constructing explanations (for science) and designing solutions (for engineering) * Obtaining, evaluating, and communicating information   **Crosscutting Concepts**   * Cause and effect: Mechanism and explanation * Energy and matter: Conservation   **Disciplinary Core Ideas - PS 3: Energy: How is energy transferred and conserved?**   * PS3.A: Definitions of Energy - What is energy? * PS3.B: Conservation of Energy and Energy Transfer - What is meant by  conservation of energy? How is energy transferred between objects or systems?   **Physical Science Essential Standards**  A seamless integration of science content, scientific inquiry, experimentation and technological  design will reinforce in students the notion that “what” is known is inextricably tied to “how”  it is known. A well-planned science curriculum provides opportunities for inquiry,  experimentation and technological design. Teachers, when teaching science, should provide opportunities for students to engage in “hands-on/minds-on” activities that are exemplars  of scientific inquiry, experimentation and technological design.  **PSc.3.1 Understand the types of energy, conservation of energy and energy transfer.**  PSc.3.1.1 Explain thermal energy and its transfer.  PSc.3.1.2 Explain the law of conservation of energy in a mechanical system in terms of  kinetic energy, potential energy and heat. | |
| **Learning Outcomes** | * Students will use technology to interpret the correlation coefficient to distinguish between correlation and causation. * Students will download, process, and analyze real-world data to demonstrate how to assess the fit of a function by plotting and analyzing residuals. * Students will demonstrate competence in use of spreadsheets and graphing calculators to analyze data and make interpretations/predictions based on data analysis. * Students will demonstrate how to determine and justify explanations of causes to temperature change within a closed environment using the law of conservation of energy. * Students will be able to identify several factors that contribute to the complexity of explaining thermal energy, its transfer, and conservation. |
| **Time Required and Location** | Five 85-minute class periods |
| **Materials Needed** | List of Materials Needed for each group (four to five students per group):   * heat lamp * aluminum tray (with plastic lid) * assortment of moss, sand, clay, black /white stones * water, 250 ml beaker or cup * medium size post-it packs or substitute index cards   **Technology Resources**  List of Technology Resources needed for each group (four to five students per group):   * Vernier Labpro * Computer with Vernier Logger Pro software or graphing calculator (e.g. TI-84) with EasyData App * Vernier Stainless Steel Temperature Probe & CO2 Gas Sensor Probe   (Note: graph paper and a thermometer could be used in place of items listed, but more time would be needed to complete the activity, and temperature changes along with qualitative observations can be noted regarding effects of CO2 if a Vernier CO2 probe is not available). |
| **Safety** | Follow typical lab safety procedures. |
| **Participant Prior Knowledge** | * Students should be able to enter data in list on a graphing calculator and on a spreadsheet. * Students should have some experience with plotting scatterplots and regression modeling. * Students should be able to use temperature probes with a Lab Pro device, Logger Pro software, and a computer (this activity may be modified to use thermometers, data charts, and graph paper or a graphing calculator). * Math concepts like correlation coefficient and causation should have already been introduced just prior to these activities. (If not, then more days need to be added to allow for students to grasp these concepts that are to be used in these explorations). * Previous lessons should have included potential energy, kinetic energy, law of conservation of energy and heat transfer.   [Note: The big idea in the lessons of this week is to give students an opportunity to apply their newly acquired knowledge and understandings of data analysis. This week, in its original context of lessons, is the last week of a four week unit on Energy Efficiency and Data Analysis]. |
| **Facilitator Preparations** | **Teacher Preparation**   * Obtain Materials Needed (see list) * Set out Technology Resources Needed (see list) * Determine lab groups/teams (see Materials and Technology list for group size limits) – even numbers of groups will work best since hot/cool teams will need to confer |
| **Activities** | Day 1 – **[Hot & Cool Environments]**  ***Destination:***  *Students will be able* to identify several factors that contribute to the complexity of ensuring a habitable air temperature on earth and raise questions about other possible factors by using an aluminum tray with a lid, a heat source (heat lamp or sun), water, sand, stones, clay, and moss to design a hot/cool environment.  *Students will demonstrate* how to determine and justify explanations of causes to temperature change within a closed environment by:   * Identifying independent and dependent variables * Designing an experiment * Making observations - measuring and recording temperature changes * Forming justifications for explanations based on data collection and analysis * Ranking items/variables (surface materials) that impact temperature changes * Collaborating with others in a scientific discourse   **Begin**  **Say:** Today, we will begin a lab exploration and discussion that we will continue for several days. The essential question for today’s focus is:  **How can we best create hot and cool environments with the materials given?**  Here are your materials.  (Either distribute, or have students get their trays with materials already in them. ***Avoid writing or saying anything that would explicitly allude to the specific topic of Climate Change.*** This will come out later in discussion of exploration.)    ***Exploration*:**  **Say:** Use the materials and temperature probes provided to create an environment (with the lid on) that is the hottest/coolest (half the groups – hottest temperature possible & half the groups – coolest temperature possible), and record the temperature using Logger Pro software. One hot team and one cool team should use the same Lab Pro device each with their own temperature probe, so that both the hot and cool graphs appear on the same graph. All groups must use materials that are being considered within a closed environment (lid on), and with a light source placed the same distance and angle away from the center of the top of the tray.  **Say:** The competition between each of the hot-cool pairings is to design an experiment that achieves the greatest temperature difference between the two physical models.  **Say:** Take five minutes to discuss in your hot or cool group how you will accomplish your task. Record your challenge, team process and decision in your science journals.  (Allow groups to work on challenge. Walk around to informally listen to student ideas. Be sure not to talk during this time, unless behavioral redirection is necessary.)  (After five minutes)  **Say:** The five minutes are up. Does anyone need more time to record your challenge, team process and decision in your science journals, and draw a sketch?  (Allow up to three more minutes for groups to finish if needed.)  **Say:** Now, take five minutes together to create the environment you have discussed, planned, recorded, and sketched. When you have finished, stand by your creation (appearing very hot or very cool) and look at me to indicate you are ready to move to the next step.  (After five minutes and students are ready - give directions for inserting the temperature probes).  **Say:** Insert temperature probes this way, (show students how to close the lid on the probe cord to hold it horizontally in place above the surface of their created space).  **Say:** Coordinate with your partner hot/cool team and connect the temperature probes into the Lab Pro and connect the Lab Pro to a common computer to share the same graph space.  (Walk around offering any assistance with equipment that may be needed. Be sure that group members have discussed how to proceed before becoming the problem-solver.)  **Say:** When both your hot/cool partner teams are ready, turn on the light source and begin collecting data for ten minutes. While you are waiting, draw a sketch and label it in your journal of what you have decided to create. Be sure to record why you think your plan will create a hot or cool environment. Record lab materials and corresponding functions in a table.  (Table below is an example, have students create their own table of materials and functions.)   |  |  | | --- | --- | | **Lab Materials** | **Function** | | Light Source | Light & Heat | | Aluminum Tray | Container for materials, Provides Shape | | Plastic Lid | Keeps Heat in Container | | Moss, Sand, Clay, Black Stones, Water | Surface where Heat is Absorbed | | Temperature Probe | Monitors Air Temperature |   (Circulate among the groups to see that everyone has gotten started in the manner described.)  **Say:** It has been ten minutes. Stop collecting data, and save a copy of the exploration data onto your USB drive. Leave the graph on the screen of your computer. Sketch the graph in your journal, and make a comment regarding any temperature difference between the hot/cool setups.  **Say:** Each hot/cool partner team take some chart paper and together write/sketch what you believe you did to get the results you got in the temperature differences. Be sure to record the temperature difference and graphs. Post or leave the chart beside your two model environments.  **Ask:** Which hot/cool partner teams has the greatest temperature difference?  **Say:** We are going to do a Gallery Walk, and each student should take two post-its for each hot/cool partner charts and write a response for each setup as to why you believe the hot/cool setups are getting their results. Share something you believe is helping to get a large temperature difference (“I Notice…” on one post-it) and share at least one thing that you believe could be changed to yield a greater temperature difference between the hot and cool environments (“I Wonder…” on your other post-it). You will have two minutes at each station. [give directions to organize gallery walk movement] Are there any questions?  (Allow enough time for the Gallery Walk to be completed.)  **Say:** Return to your original station setup. Take five minutes to discuss with your hot/cool partner teammates the feedback given by others and why you think you got the results that you have, and then discuss what you could change that might have a greater impact. Do not make any changes with your created environment. Record the key points of your discussion in your journal.  (Walk about and check that students are recording key points of discussion in their journal.)  ***Model System:***  **Say:** Let’s take five to ten minutes and discuss as a whole group what we believe this means in the context of the law of conservation of energy and heat transfer.  (Lead a discussion by asking open-ended questions to guide students in recognizing connections between their models and planets in general and the earth. Include Key Points about previous lessons on Potential Energy, Kinetic Energy, Heat Transfer, & Law of Conservation of Energy).  **Say:** Remember to record the questions and the key points of this discussion in your journal.  (It would be helpful to have these questions written down – either on the board, on chart paper, or electronically projected. Students could also respond electronically in a wiki, blog, etc.)  Questions to consider are:   * **What might these model environments symbolize on a larger scale?** * **In what ways did your group use a method to guide your decisions?**   Analysis of Experimental Variables  Variables   * **List all the materials you can change during an experiment.**   Independent Variable   * **Which variable can the experimenter purposely change?**   Dependent Variable   * **Which variable will respond to the change in the independent variable?**   Experimental Controls   * **Which factors will not change during the experiment?**   *(Example – How important is it to keep the light source the same distance away?)*   * **What did the lab materials symbolize?**   (Complete this table as a large group, and have students add to their tables in their journals.)   |  |  |  | | --- | --- | --- | | **Lab Materials** | **Function** | **Model System** | | Light Source | Light & Heat | Sun | | Aluminum Tray | Container for all other materials, Shape | Earth | | Plastic Lid | Keeps Heat in Container | Atmosphere | | Moss, Sand, Clay, Black Stones, Water | Surface where Heat is Absorbed | Earth’s Surface | | Temperature Probe | Monitors Temperature | An Indicator of Climate Change |  * **Which factors had the greatest impact on your model earth’s temperature?** * **How might you now change your environment to model planet earth so that a moderate temperature range may be maintained to support life as we know it?**   ***Content Wrap Up:***  **Say:** Let’s take a moment to clarify the results of today’s explorations and our discussions. Be sure to journal key points to ponder for further study or use in your next explorations.  **Ask:** What can we learn fromour hot/cool environments today?  **Informal Assessment Questions**  1. How has your modeling of hot and cool environments helped you to understand the role of the earth’s atmosphere and surface areas in maintaining a healthy temperature range on earth?  2. How do hot and cool environments designed today model climate change on earth?  3. What evidence did you see today that types of surface materials seem to impact air temperatures above the surface?  4. What observations did you make today that may suggest small changes can have big impacts?  5. How did the use of technology help us observe changes in our climate model system?  (Generate a class list of clarifications as students share their insights, like the ones listed below.)  [If time allows, or as an **alternative informal assessment**, try a **simultaneous round table** activity. This is where students individually write a response on paper or index card to the teacher’s prompt question(s) and then passes their paper/card in a clockwise manner so each person gets someone else’s card. Then they read it and write another response regarding the prompt or in connection to what someone else wrote. Additional questions for student response may be asked until cards have returned back to their owner. Once each student gets their own card back, they can write a response to reflect what they have learned from their peers. If time is short, consider an **exit** **ticket** activity where students respond to one of the questions above on an index card and give to you on their way out of class. Look over the responses to see if there are any misconceptions or confusion that may be addressed in the next class period.]  (Note: More information on the Simultaneous Round Table activity, as well as other helpful activities for students to process their ideas with each other may be found in Pearson’s The SIOP Model for Teaching Science to English Learners by Deborah J. Short, MaryEllen Vogt, and Jana Echevarria on page seventy-five.)  **Climate Change Impacts – Observations & Typical Student Responses**   * The earth’s atmosphere is crucial for ensuring a habitable temperature range. * There are a variety of considerations one needs to examine to understand climate change. * The types of surface materials seem to impact air temperatures above the surface. * Small changes can have big impacts. * The use of technology can help us observe changes in our climate and determine causes.   (Note: Save the environmental setups to be used in the next day’s lesson).  **Guided Practice**  [If time, allow for redesign and further experimentation].  **Say:** Talk with your team and make any changes you would like to try to make a greater temperature difference with your hot/cool partners. You have three minutes for this discussion and to make any changes.  (Allow three minutes for discussion and changes).  **Say:** Set up the temperature probes as you did before and repeat experiment with your changes.  Journal about your data results, graph, and observations comparing and contrasting with your earlier results.  [If time does not allow for any more in-class experimentation, assign as an outside of class written journal assignment].  **Assessment**  Students will be able to identify several factors that contribute to the complexity of explaining thermal energy, its transfer, and conservation.  Listen for what students think will create a hot or cool environment. Observe students as they use temperature probes, graphing calculators, and computer spreadsheets to discern levels of competence with various technologies to collect and analyze data. Students record in their science journals their challenge, team progress, decisions, sketches, and why they think their plan will work. Encourage students to include tables of materials and functions listed in their journal. The gallery walk will engage students in an authentic manner. Ask students to use post-it notes to leave comments in the format of “I Notice, “I Wonder”. Listen in as groups discuss the results of their gallery walk experience. Key points of this discussion should be included in the student’s journal.  Day 2 - **[Global Climate Change Impacts]**  ***Destination:***  *Students will be able* to use technology to interpret the correlation coefficient to distinguish between correlation and causation, and to use the law of conservation of energy to explain why CO2 and H2O are important to understand in the efforts to lessen climate change impacts.  *Students will demonstrate* how to mathematically interpret data by plotting and analyzing residuals to analyze real-world data regarding changes in climate, make predictions about impacts due to human activities, and offer recommendations for needed changes.  **Begin**  **Say**: Today we will explore the effects of a greenhouse gas (CO2) on temperature in the model environments you created yesterday, and in real-world climate data sets.  ***Exploration: (students should be in the same teams as the day before)***  **Say:** Each (hot/cool) team must use at least 100 ml of water, but not more than 250 ml of water to make a small pond or ocean in their enclosed environment (model earth system). Setup one CO2 probe in one of the environments and wait for 90 seconds. Record the CO2 reading in one environment and then in your partner team’s environmental setup. Be sure to allow about 90 seconds for the CO2 monitor to stabilize before recording a starting CO2 level.  (Allow 90 seconds for the CO2 probes to stabilize before measurements are recorded.)  (Allow for the CO2 probes to stabilize and measurements to be recorded.)  **Say:** When you have recorded the CO2 measurements, remove the CO2 probe from your model and disconnect the CO2 probe from the Lab Pro.  **Say:** Now, once both hot and cool partner teams are ready - simultaneously take two Alka Seltzer tablets for each team, and place them into the pond/ocean (wet areas) and close the lid immediately. Turn on your heat source (the sun) and begin a new data set to collect temperature data for thirty minutes.  (Allow time for students to begin the collection process.)  **Say:** While we are waiting for your experimental data results, let’s explore some real-world data sets regarding CO2 and temperature.  **Say:** Get a computer (one per group, pair or individual student if available) and go to this website: [**http://www.esrl.noaa.gov/gmd/aggi/AGGI\_Table.csv**](http://www.esrl.noaa.gov/gmd/aggi/AGGI_Table.csv) (see Excel Scatter Directions)  The data should automatically download as an Excel Spreadsheet.  (instruct students, as needed, to create a scatterplot of this data - Year to Total columns)  (**Think-Pair-Share Informal Assessment**)  **Say:** Get Linear Regression equations for the Total and CO2 data and compare – note your findings and sketch the results with the two regression equations in your journals. Then turn in pairs to compare your thinking about these graphical results.  (After students have had a chance to journal their own response and share in pairs, ask students to share with the whole class the thinking of their pair discussions).  **Ask:** What is the significance of these findings?  (After students share, ask for reflections around association versus causation).  **Ask:** How can we know whether the CO2 is simply a correlation or is indeed a causation of the rise in global gases and therefore a major contributor to global warming?  (After students share their ideas, mention that this will be the exploration for the next class).  **Say:** Now, let’s check on your experimental graphs and save our results. Email or print out the results to everyone in your partner team.  **Say:** Take two minutes to discuss the graph results in your partner teams. What did the Alka Seltzer tablets add to this enclosed environment? How did this impact the results of your Climate Change Model?  (Allow time for discussions.)  ***Model System:*** Earth’s Climate conditions with increased CO2 emissions increase.  **Say:** Go To this website [**http://www.exploratorium.edu/climate/index.html**](http://www.exploratorium.edu/climate/index.html) and explore the effects of increasing CO2 emissions over time. Look for questions 1-4 on the website and use the website information, data, and simulations provided to write your response in your journal.   1. Why is measuring carbon dioxide in the atmosphere so important in understanding global climate change? 2. [Why is carbon dioxide such an important greenhouse gas? Don’t other gases exist in the atmosphere in much higher concentrations?](javascript:;) 3. How likely is it, that climate change will have significant global effects in the next hundred years? 4. Why is predicting future climate so difficult? 5. Write your own question based on your own research, data analysis, and this site. Answer your own question.   (Allow students time to work and write their individual responses to all five questions.)  ***Content Wrap Up:***  **Say:** We are now going to create four groups to discuss our responses to the first four questions.  (Divide up the class into four groups and assign one of the four questions to each group. Have the groups discuss their response and come to an agreement about their group response to the question assigned to them. Ask each group to have a recorder of their discussion’s key points, a coordinator to keep the group moving, and a spokesperson to share out with the larger group their group’s response to their assigned question.)  [After a few minutes for the groups to discuss their question and response, ask the spokespersons to report out their group’s response to the whole class. Check for understanding of the website information, meaning of data and simulations as the whole group reflects on the questions that follow.]  **Informal Assessment Questions**   1. Why is measuring carbon dioxide in the atmosphere so important in understanding global climate change? 2. [Why is carbon dioxide such an important greenhouse gas? Don’t other gases exist in the atmosphere in much higher concentrations?](javascript:;) 3. How likely is it, that climate change will have significant global effects in the next hundred years? 4. Why is predicting future climate so difficult?   If time, ask individuals to share the question in item number five that they wrote and their answer based on research and data analysis. If time constraints do not allow for individual sharing, then have students post the question they wrote and their answer either online or within the classroom for others to read and comment regarding the validity of sound data research and analysis.   1. What question based on your own research, data analysis, and the Exploratorium website did you write? How did you answer it?   [Note: See Suggested Answers from Exploratorium Website attachment for questions 1-4. Emphasize scientific discourse based on research and data analysis in student responses to these four questions and the one they write and answer].  **Guided Practice**  (Finding & Accessing Class Research Resources; Practicing Socially Connected Research)  Students will:   * Conduct Graphical Analysis & Complete Formative Interactive Online Quizzes * Use an online website to explore the effects of CO2 , Global Climate Electronic Interactivity Re: CO2 Impacts * Discuss/analyze the Impacts of CO2 as a Class * Engage in an electronic class discussion of findings (use class blogs or wiki)   **Assessments**  Students will demonstrate how to determine and justify explanations of causes to temperature change within a closed environment using the law of conservation of energy.  Give students multiple opportunities to explain thermal energy and its transfer. Ask students to use the law of conservation of energy in a mechanical system in terms of kinetic energy, potential energy and heat from previous lessons to explain climate change impacts of heat trapped by CO2 in our atmosphere. Assist students in their efforts to use technology to interpret the correlation coefficient to distinguish between correlation and causation. Students should demonstrate they can plot and analyze residuals in the process of interpreting data, making predictions, and proposing recommendations. As you move around from student to student, group to group, note who is able to access real-world data and use spreadsheets to conduct data analysis. Offer assistance to those students who still struggle with some of these data analysis tools and methods. Listen as Think-Pair-Share groups discuss, and make any corrections, or clarifications in a whole group sharing time. Have students get two linear regression equations for data and compare. Students should note findings, correlation versus causation discussion, and sketch in their science journals. Students will encounter an online interactive assessment on the Exploratorium website as they interact with real-world model systems regarding climate change model systems. The four questions asked on the website and discussed with other students should be documented in their journals. The fifth question written and answered by each student should be supported with documented evidence based on research and data analysis.  Day 3 – **[National Climate Change Impacts]**  Students will practice finding quality data websites, downloading data into excel, processing, interpreting, and sharing data research and analysis of residuals, correlation, & causation with another group.  **National Climate Change Impacts by Region & Sector** data as presented on the U.S. Global Change Research Program website: <http://www.globalchange.gov/> will be researched by students.  <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report>  Process Format used: **Base & Expert Groups** in Socially Connected Research Collaborations  (One member of each base group seeks to become an expert along with one person from each of the other groups on a specific region and sector. Students will first work together in their expert groups to build competence and confidence in the use of spreadsheets and graphing calculators to analyze data and make interpretations/predictions, noting associations and causations in data related to their specific region and sector. Circulate among the groups offering help when needed to clarify spreadsheet/calculator procedures. After about forty-five minutes, students are to return back to their base groups - each member now an “expert” in some region and sector as well as in the use of spreadsheets and graphing calculators. Have the students share what they learned about their specific region and sector with each other in their base groups.)  **Guided Practice**  Students will:   * Practice researching, downloading, processing, interpreting, and sharing data research. * Practice using spreadsheets and graphing calculators to analyze data. * Practice finding residuals and discussing correlations versus causations.   **Assessments**  Students will use technology to interpret the correlation coefficient to distinguish between correlation and causation.  Students are to compute (using technology) and interpret the correlation coefficient of a linear fit. To do this they are to practice finding and downloading quality data from appropriate websites (listed in document and as attachment). They should use spreadsheets to process, interpret and share data research and analysis of residuals, correlation, and causation with another group. Students will discuss climate change and receive help from one another in using spreadsheets and graphing calculators to analyze data and make interpretations/predictions. They should note any associations and causations in data.  Days 4-5 - **[National Climate Change Impacts by Region & Sector]**  New Regions and Sectors not yet explored will be assigned randomly to all. Students will demonstrate competence in use of spreadsheets and graphing calculators to analyze data and make interpretations/predictions based on data analysis regarding their assigned region and sector. Students should include in their analysis the major components listed below (see attached Climate-Impacts-Report).  **Math:**   1. **Scatterplot (2 variables) How are variables related?** 2. **Computer & Calculator to plot and analyze residuals** 3. **Spreadsheet to interpret correlation coefficient of a linear fit** 4. **Correlation vs. causation**   **Science:**   1. **Explain thermal energy and its transfer …** 2. **Explain the predicted climate impacts on the United States by Sector** 3. **Explain the predicted climate impacts on United States by Region** 4. **Use the Law of Conservation of Energy to write an explanation about climate concerns for assigned region and sector based on data analysis.**   **Assessments**  Students will individually demonstrate competence in use of spreadsheets and a graphing calculator to analyze data and make interpretations/predictions based on data analysis.  Students will evaluate published reports and data of National Climate Change Impacts by Region and Sector on a previously used website ([www.globalchange.gov](http://www.globalchange.gov)). They then should determine the appropriateness of the data analysis, and the validity of their conclusions based on data.  Students will download, process, and analyze real-world climate, CO2, temperature, and global warming online research data and questions to demonstrate how to access and assess the fit of a function by plotting and analyzing residuals. (Climate, CO2, Temperature, and Global Warming Online Research Questions [**http://www.exploratorium.edu/climate/index.html**](http://www.exploratorium.edu/climate/index.html)).  Learning Outcomes and associated assessments are spread throughout the week. Informal Formative Assessments may be made frequently by asking questions, observing, think-pair-sharing, class discussions, models,simultaneous roundtable, use of base and expert groups, journals, graphs and written analysis. A rubric is available as an attachment for a summative evaluation (see attached Informational Research Paper Rubric) of student understanding and application of previously learned lessons applied to a study on Climate Change Impacts and Energy Efficiency. |
| **Critical Vocabulary** | Climate. Climate refers to long-term patterns in the earth’s weather. Tendencies for large areas of the planet to be wet, dry, hot, or cold are examples of climate. Weather, on the other hand, refers to short-term events, such as daily or weekly temperature and precipitation.  Weather. Weather refers to short-term phenomena, such as daily temperature, precipitation, and wind patterns. Longer-term patterns—such as fluctuations in temperature over years or decades—fall under the heading of climate.  Carbon dioxide. Carbon dioxide (CO2) is one of the gases produced when fossil fuels are burned. CO2 in the atmosphere helps keep the earth warm, because it traps heat near the planet’s surface—a process called the greenhouse effect. CO2’s molecular structure allows sunlight to penetrate the atmosphere and heat the earth’s surface, but prevents heat from escaping back into space. CO2 is one of the most important greenhouse gases, because human activity directly affects its concentration in the atmosphere.  [**http://www.exploratorium.edu/climate/global-effects/index.html**](http://www.exploratorium.edu/climate/global-effects/index.html)  **Heat-Trapping Gases**  ***Human activities have led to large increases in heat-trapping gases over the past century.***  **Carbon Dioxide** – concentration has increased due to the use of fossil fuels in electricity generation, transportation, and industrial and household uses.  **Methane** – concentration has increased mainly as a result of agriculture, raising livestock, mining, transportation, and use of certain fossil fuels; sewage; and decomposing garbage in landfills.  **Nitrous** **Oxide** – concentration is increasing as a result of fertilizer use and fossil fuel burning.  **Halocarbon** – emissions come from the release of certain manufactured chemicals to the atmosphere. Examples include chlorofluorocarbons (CFCs).  **Ozone** – is a greenhouse gas, increasing near the surface by human activities by releasing gases such as carbon monoxide, hydrocarbons, and nitrogen oxides. These gases undergo chemical reactions to produce ozone in the presence of sunlight.  **Water** **Vapor** - increases in other greenhouse gases leads to an increase in atmospheric water vapor, since a warmer climate increase evaporation and allows the atmosphere to hold more moisture. This creates an amplifying “feedback” loop,” leading to more warming. |
| **Modifications** | Some students may need:   * a study guide and highlighted material to help them understand written words, phrases, and sentences on the websites being used to collect data; * to use text-to-speech technology to communicate directions on the websites where data is accessed; * another student who can help them when the teacher is busy; * more clear, short, and specific directions; * spoken directions to also be given in written form and vice-versus; * lists or numbering on a checklist that provides detailed guidelines; * to repeat directions in their own words to check if they understand; * alternate ways to demonstrate what they have learned; * to use graph paper and thermometers in place of Vernier Probes; * help to break down the task into its component parts; * more visuals, like graphic organizers and pictures; * the teacher to check with them more frequently regarding comprehension; * to download real-time data in advance to have enough time to process the data in class; * interest-based extension activities; * more complex questions and open-ended research opportunities. |
| **Alternative Assessments** | Write a story illustrating how data may sometimes be a correlation between two variables only and sometimes data can clearly show causation.  Traditional tests for displaying linear data and finding the linear regression equations may be given. |
| **References** | Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.) Cambridge University Press, 2009, (pages 14-15).  Greenhouse Gases Data[**http://www.esrl.noaa.gov/gmd/aggi/AGGI\_Table.csv**](http://www.esrl.noaa.gov/gmd/aggi/AGGI_Table.csv)  NOAA Climate Services[**http://www.climate.gov/#climateWatch**](http://www.climate.gov/#climateWatch)  Exploratorium[**http://www.exploratorium.edu/climate/atmosphere/index.html**](http://www.exploratorium.edu/climate/atmosphere/index.html)  Global Climate Change Impacts in the United States [**http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report**](http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report) |
| **Supplemental Information** | **ANNUAL GREENHOUSE GAS INDEX (AGGI)** [**http://www.esrl.noaa.gov/gmd/aggi/**](http://www.esrl.noaa.gov/gmd/aggi/)  “Of the five long-lived greenhouse gases that contribute 96% to radiative climate forcing, CO2 and N2O are the only ones that continue to increase at a regular rate.”  “The Intergovernmental Panel on Climate Change (IPCC) defines climate forcing as “An externally imposed perturbation in the radiative energy budget of the Earth climate system, e.g. through changes in solar radiation, changes in the Earth albedo, or changes in atmospheric gases and aerosol particles.” Thus climate forcing is a “change” in the status quo. IPCC takes the pre-industrial era (arbitrarily chosen as the year 1750) as the baseline. The perturbation to direct climate forcing (also termed “radiative forcing”) that has the largest magnitude and the least scientific uncertainty is the forcing related to changes in long-lived and well mixed greenhouse gases, in particular carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and halogenated compounds (mainly CFCs).”   * Aerosols and Climate (attached) * Carbon Monitoring (attached) * Climate Models and Their Evaluation (attached) |
| **Comments** | These lessons, as they were originally taught, represent Part Three of a three-part Unit on Energy Efficiency during a four-week project-based learning unit. Part One of the unit focuses on Human Efficiency. Part Two focuses on Building Efficiency. This series of lessons over a five day period focuses on Planet Efficiency and may be expanded over more time as needed, or a given day’s lesson may stand alone as a supplemental lesson with some minor modifications. An additional resource used as a part of this overall unit in its original context was the Unit 4 on Regression and Correlation of the Core Plus Integrated Mathematics Course Two textbook. Lesson two, investigations three and four, on understanding associations and the differences between correlation and causation served as a background for students to gain understanding of the mathematics needed for their research analysis. |
| **Author Info** | Allen Nice-Webb, is a National Board Certified Teacher in Mathematics, a Kenan Fellow, and is dually certified in both Math & Physics. Allen teaches at a New Schools Early College high school, Buncombe County Early College in Asheville, North Carolina.  He is the founding teacher of IMAPS - Integrated Math & Physical Science course. IMAPS is a blended Integrated Math and Physical Science Course for our Year 1 (9th grade) students. He is certified to teach Math, Physics, General Science, and Bible in the state of North Carolina. He has been teaching for over twenty-seven years in traditional and alternative school settings.  He has taught math and science in both private and public schools ranging from fourth grade to twelfth grade. He has also taught adult learners within community college developmental mathematics courses. There have been times when he has stepped out of the public school system to teach youth and young adults in other ways, by serving as:   * Positive Youth Development Lead Trainer for The B.E.S.T. Initiative (Professional Development for Youth Workers) in Philadelphia, serving a variety of programs within 62 youth-serving organizations * Master Teacher for a Motivational Educational Training Center * Developmental Mathematics Educator for Community Colleges * Outdoor School Educator at a year-round Retreat Center * Low-Ropes Course Initiatives Trainer for youth groups, camps, Americorps, YMCA Directors, and community centers * Student preparation trainer for multi-state high-stakes assessments * Math tutor and Science teacher for Upward Bound students * Conference Youth & Young Adult Minister for 54 Congregations in northeastern U.S.A. * Campus Pastor for students in a private high school * Church and Community Mediator, including youth and young adults * Youth & Young Adult Retreat Speaker   Before developing a four-week unit on Energy Efficiency, Allen interviewed resource people from his community to gather ideas and to build a network of potential connections to support his efforts with this lesson and others throughout the school year.  Community contacts gained in preparation for this unit are:   * Dr. Thomas C. Peterson, Senior Scientist of NOAA’s National Climatic Data Center in Asheville, NC and President of the World Meteorological Organization (WMO) Commission for Climatology * Jon Snover, Director of the Global Institute for Sustainability Technologies (GIST) * John Brock, Interim Director of the Environmental Leadership Center at Warren Wilson College – he is currently developing a course: Pollution and Human Health * Laurie Stradley, Director of State and Community Collaboration with the NC Center for Health and Wellness located on the UNCA campus * David Gardner, Executive Director of the NC Center for Health and Wellness located on the UNCA campus * Keith Bamberger, NC Department of Environment and Natural Resources, Division of Air Quality   Each resource connection was very encouraging and a part of nurturing this lesson, the lessons before this one, and others later in the school year. Dr. Peterson proved to be most inspiring of a direction to go with the study of Climate Changes and graciously gave a resource book to Allen called Global Climate Change Impacts in the United States, which he was one of the Co-Editors.  The community resource connection was so great, that numerous lessons may be developed over the next year. Allen plans to revisit similar topics in the latter part of the school year as a culminating interdisciplinary project concluding with a community-wide open symposium conducted in a student-led conferencing format. Parents, community leaders, media representatives, other schools, and resource contacts will be present to interact and to deepen the discussion for our entire community.   * Joyce Gardner of the Department of Public Instruction (DPI) was Allen’s mentor and offered counsel, resource connections, and direction when needed. She led by example in summer institute trainings and gave Allen some experience in the training process by asking him to help in the training at times. In these experiences, Allen developed new electronic resources that may be used later on in his training of other teachers and with his own students. |