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My Future, My Home: Building a Greener House for Tomorrow

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Introduction

More and more frequently, it seems as if the news headlines have been taken straight out of a script from a disaster film. *Greenland Ice Sheet is Melting at Unprecedented Rate.Wildfires Ravage California, Forcing Thousands to Flee Their Homes. Sea Levels Rise, Threatening Coastal Communities.* The term 'natural disaster' has evolved into something of an oxymoron. Many of the consequences of climate change and global warming have been exacerbated by our own behaviors, attitudes and ways of consuming resources, particularly fossil fuels.

In real life there is no A-list actor ready to jump in and shepherd civilians to salvation. My three- week unit (titled "My Future, My Home: Building a Greener House for Tomorrow") is designed for 6th grade students to realize that every one of us must become environmental heroes in order to ensure the long-term survival of humanity and other species while allowing the Earth to thrive.

Our modern way of life relies on a tremendous amount of energy consumption in all we do, from driving, shopping and entertainment to preparing our meals and staying comfortable in our homes. Fossil fuels have been our primary source of energy since the industrial revolution started in the 1760s. With the invention of the steam engine that utilized coal to power its engine, the world's annual coal production has increased 800-fold as of 2006 and continues to rise.[1] Our use of other fossil fuels such as oil and natural gas is equally egregious. For example, we have used one trillion barrels of oil in the last 140 years.[2] These consumption practices are not sustainable, and they threaten the long-term survivability of human beings and other living species on Earth.

One result of our exorbitant use of fossil fuels is a significant increase in the amount of CO_2 in the atmosphere, which multiplies Earth's natural greenhouse effect. In the last few decades, global warming, or a rise in average temperatures around the world, has been the most noticeable and damaging outcome. Global warming has reduced the size of the polar ice caps and glaciers while increasing the frequency of droughts and heat waves, as well as causing higher ocean temperatures. Taken on their own, each of these phenomena is disastrous, but all together their consequences are catastrophic. Environmental scientists are currently warning that if we do not curb our use of fossil fuels in a profound way within the next 10 years, global warming will not be able to be mitigated.

Background

Herbert Hoover Middle School is located just west of downtown San Jose, California. It is one of six middle schools in the San Jose Unified School district. Most of the families served by Hoover Middle School live in the downtown area. Hoover is classified as a Title I school. With enrollment in San Jose Unified currently declining due to the high cost of living in Santa Clara County, the size of Hoover's population typically fluctuates year over year.

Currently, Hoover's population is comprised of approximately 1,100 students. More than 700 Hoover students qualify for free or reduced lunch. The school's Ethnic Diversity Index score was characteristically low (26 out of 100), with 77% of all students self-reporting their ethnicity as Hispanic or Latino. Six hundred fifty Hoover students claimed a primary language other than English, with 327 of those ELA students assessed as English Learners (not yet fluent in English). Spanish was the predominant first language of the English Learners at Hoover (96%).[3,4]

Hispanic students have scored behind other subgroups in both Language Arts and Mathematics on state testing, so reaching this group in ways that are meaningful and accessible is important in my unit.

When my students are able to make connections to my Science curriculum because it seems relevant to their lives, their interest and participation are typically high. Most of my students enjoy Science, particularly when we are doing hands-on activities or group work. When they are learning about things they can carry into their daily lives, my students are excited and eager to apply themselves. My students work best when solving challenges that relate to their daily lives. A handful of my students take pride in their leadership skills and ability to influence others.

Many of my students come from low-income families and face difficult social and emotional challenges at home. One of my driving goals as a teacher is to help each of my students understand the positive impact they can have through their actions and attitudes. Frequently, I can reinforce this using my Science lessons.

Rationale

Empowering students to become active participants in making a better future for themselves and our environment is a driving rationale behind my unit. Students' awareness of the consequences of their energy consumption behaviors will be heightened, helping them to make more informed decisions about impacting the environment in their daily activities. My intention is for them to pass this information on to their family members, friends and other people in their circles of influence to have a broader positive outcome. Since many of my students are in low-income families, we will come up with practical ways for people to adopt greener life habits that are also cost-effective. These include more frequent use of public transportation or carpooling and energy conservation efforts like turning appliances and lights off when not needed and limiting electronics use.

By including real world examples taken from students' households and actions, as well as having a strong tie to local California challenges, my unit will feel very relevant to students. Based on my past experiences in the classroom, students will be highly engaged and motivated during my unit because they can connect it to their own lives.

The vision of our district is to prepare students to be thinkers, leaders and creators of tomorrow. My unit supports this vision by incorporating critical thinking skills and a creative home design project, as well as giving students the knowledge to become environmental leaders in the future. With its focus on global warming and fossil fuel consumption, my unit also aligns with the California Next Generation Science Standards.

Content Background

While doing my research for the Yale National Initiative program, I realized that climate change and humanity's culpability through our energy use practices was something I knew very little about. I had never studied energy consumption in college and had only done a cursory investigation on it in my own teaching. Now, I see energy consumption and climate change in our headlines on a daily basis as a hot-button political issue and an environmental crisis. Global warming has also become part of our Next Generation Science Standards as we attempt to address the factors that have led to the rise in global temperatures.

Fossil Fuels and Energy Use

Fossil fuels are a non-renewable resource that humans rely heavily upon for our energy usage. Fossil fuels are the organic remains of biological materials "left in the ground during the Carboniferous Period between 360-286 million years ago".[5] During this era, the land over a majority of the Earth was covered by swamps. Over time, the marine biomass of dead plants and animals sank to the bottom of the swamps and oceans where it formed a substance called peat. The peat was covered by various materials, including sand, clay and silt. Depending on the type of organic matter, surrounding material, temperature, amount of pressure and length of time the biomass was buried, the peat transformed into various fossil fuels. The major types of fossil fuels are coal, oil and natural gas.[6]

People have been burning fossil fuels in large amounts for our needs at an unchecked rate. In *Energy for a Sustainable World*, authors Nicola Armaroli and Vincenzo Balzani state that "over 80% of energy [currently] used by mankind comes from fossil fuels."[7] Americans are particularly gluttonous in their energy consumption, with average Americans consuming twice as much as Europeans, four times that of Chinese, 17 times Indians and 240 times more than Ethiopians.[8] "It has been calculated that if all the world's 6.8 billion inhabitants were to live at current American ecological standards, we should look around for another four Earths to accommodate them."[9]

Fossil fuels are considered to be non-renewable because they take millions of years to form. They do, however, have multiple economic advantages over other forms of energy. Fossil fuels continue to power economic growth and industrialization of nations,[10] as well as sustaining our traditional way of life and maintaining our expectations of thriving in a global economy. The application of fossil fuels is pervasive in today's modern world, being employed in electricity production, heating, transportation and many other industries. Additionally, fossil fuels are fabricated into everyday products like furniture, deodorants, detergents, plastics and appliances. Currently, our dependence on fossil fuels is ingrained in almost everything we do and is a fundamental part of many of our social and economic systems. Breaking this reliance on fossil fuels is one of the major challenges for humanity in the 21st Century.

Climate Change and the Greenhouse Effect

One catastrophic byproduct of our abundant use of fossil fuels is the effect on Earth's atmosphere. When fossil fuels are burned for energy, carbon dioxide (CO_2) is released into our atmosphere. When fossil fuels combust or burn, they combine with oxygen to form both carbon dioxide (CO_2) and water (H_2O). Heat energy is also produced as a result of fossil fuel combustion. This energy is stored in chemical bonds that hold the carbon and hydrogen atoms together. When the atoms are rearranged, the bonds break, resulting in the release of energy. The amount of CO_2, water and energy produced from each reaction depends on the fossil fuel's carbon and hydrogen content.[11]

Many natural processes release carbon and oxygen into the environment, and much CO_2 is absorbed or removed by the oceans and plants' photosynthesis. However, the amount of CO_2 being produced as a result of our consumption of fossil fuels overwhelms the Earth's capacity to compensate. If all of humanity's carbon emissions were halted today, it would still take the Earth 100 years to naturally absorb the current levels of CO_2.[12]

The extra CO_2 being produced rises into the atmosphere, where it accelerates Earth's natural greenhouse effect. Energy comes to the Earth from the sun as sunlight. After being absorbed by the Earth, the leftover energy is radiated into space in the form of infrared radiation. Our atmosphere captures some of the outgoing infrared radiation, keeping our planet warmer than it otherwise would be. Without an atmosphere, the Earth would average about -3°F or -16°C around the world, temperatures that aren't suitable for sustaining most life that exists. With the atmosphere in place, average global surface temperatures are 86°F or 30°C.[13] Due to the increased CO_2 in the atmosphere as a result of fossil fuel consumption, much more infrared radiation is trapped and temperatures on Earth are pushed higher. This phenomenon is called global warming.

How do we know that the additional CO_2 in the atmosphere is caused by humans? One method of answering that question is to study human activity, particularly our burning of fossil fuels since the Industrial Revolution. There are several stationary sites worldwide where large amounts of CO_2 are detected in the atmosphere. Not surprisingly, these areas lie above North America, Southeast Asia and Europe, three of the most industrialized regions on Earth.[14] Over the last 2,000 years, concentrations of the three greenhouse gases -- CO_2, methane (CH_4) and nitrous oxide (N_2O) -- remained at low levels and relatively unchanged but began to spike considerably coinciding with the Industrial Revolution around 1750 and an increase in deforestation as the number and size of cities expanded. From 1850 to 2000, the total amount of CO_2 in the atmosphere increased from 280 parts per million (ppm), where it had averaged since before 0 C.E., to 375 ppm.[15] In particular, our energy use practices since 1950 have had a significant impact on the atmosphere. The increase in atmospheric concentrations of all greenhouse gases after 1950 represents 75% of the total variation since the start of the Industrial Revolution.[16]

An affirmative answer to the question of whether humanity is to blame for the higher concentration of CO_2 is also confirmed by looking at carbon isotopes. Carbon is composed of different isotopes, carbon-14, carbon-13 and carbon-12, with carbon-12 being the most common. Carbon-12 has 6 protons and 6 neutrons, while carbon-13 has 7 neutrons and the very rare carbon-14 has 8 neutrons, making it the heaviest form of carbon. CO_2 that is produced from burning fossil fuels has a different isotopic composition than that of the CO_2 that occurs naturally in the atmosphere. Since fossil fuels are ultimately derived from ancient plants and animals, they are depleted of any carbon-14 that is radioactive and would have decayed long ago. Fossil fuel CO_2 also has low amounts of carbon-13. “By comparing the amount of carbon-14 in carbon dioxide in the air, scientists are able to recognize the telltale signature of fossil fuels as the source of these emissions.”[17] Carbon emissions from volcanic activity can also be dismissed since CO_2 from volcanic activity has a higher level of carbon-13 relative to carbon-12. In our atmosphere, there is a trend toward a low ratio of carbon-13 to carbon-12. Thus, volcanoes are not to blame for climate change.[18]

In *The Long Thaw*, author David Archer asserts, “If CO_2 emissions continue it is predicted to be 3-5% warmer by 2100 than 1950.”[19] Global warming is already having devastating effects on our oceans and polar ice regions. It also has the potential to lead to significant sea level rise, more frequent severe weather events (hurricanes, storms, droughts, wildfires) and a tragic loss of biodiversity. Climate change is a reality that must be addressed. As the Intergovernmental Panel on Climate Change states, “Scientific evidence for warming of the climate system is unequivocal.”[20]

Average global temperature rise not only leads to a warmer surface of the planet but it has also led to oceans absorbing much of the heat. With 90% of the sun’s energy going to the oceans, they absorb 20 times more heat energy than the atmosphere. Covering 70% of the Earth, the oceans also absorb a majority of the CO_2 produced worldwide. The oceans’ carbon reservoir has a greater capacity than the atmosphere’s even though it is thinner (4 km compared to the 8 km depth of the atmospheric carbon reservoir). The ocean’s ability to absorb CO_2 is dependent on proper circulation of warm surface water mixing with cold seafloor water. The cold water of the oceans envelops CO_2 in the carbon reservoir layer and then bears it downward into the depths. But rising sea temperatures threaten this circulation cycle. Since cold water is denser, a greater disparity between the temperatures of surface and deep ocean water causes colder water to stay down. Climate change could bring about the stagnation of our ocean water and force the atmosphere and plant photosynthesis to take the brunt of CO_2 absorption.[21] This potential slowing or stagnation of our ocean water could have disastrous effects on our planet including changing weather patterns. Places like Europe could potentially see much colder winters and much hotter summers.[22]

Global warming is also causing a rise in the frequency and destructiveness of extreme weather events. An increase in ocean surface temperatures leads to more frequent spawning of hurricanes. It also contributes to the severity of those hurricanes. More frequent and extended heat waves are occurring around the world, with high temperature records regularly being exceeded.[23] In the summer of 2018, 22% of populated and agricultural regions located above 30 degrees latitude across the northern hemisphere suffered simultaneous extreme heat conditions. This sort of concurrent high temperature event affecting such an expansive number of locales simply did not occur before 2010.[24] The extreme heat has intensified drought conditions and fueled more disastrous wildfires. In 2018, California suffered its most expensive damage from wildfires in the state’s history with insurance claims in November alone topping $12 billion.[25]

A byproduct of the enhanced greenhouse effect caused by higher concentrations of CO_2 in the atmosphere, global warming has triggered unprecedented melting of the Greenland and Antarctic ice sheets.[26] Across the world, glaciers are shrinking. Climatologists have been measuring Arctic sea ice dimensions using weather satellites since 1979 and have determined that the ice has been declining at a rate of 12.8 percent per decade since then. In 2012, the ice sheet over Greenland suffered its worst melting ever. The summer of 2019 is threatening to be just as damaging to the Arctic ice, with some extreme Greenland temperatures in June peaking 40°F above normal.[27]

The areas covered by the ice sheets provide habitats to a great variety of wildlife; the loss of sea ice can have devastating effects on natural ecosystems. In particular, the polar bear faces a dire outcome as a species unless the course of global warming is drastically changed. Many human communities in the Arctic region, dependent on snow packs for their water, find those water sources less and less available as snow cover decreases yearly.

Due to the added water from melting ice sheets and glaciers, sea levels are rising. This causes communities and towns along coastal areas to be displaced, as well as disrupting fragile natural ecosystems along the shoreline. From 1993 to present, average sea levels are rising 3.3 mm per year, resulting in an increase of 91 mm since 1993.[28]

Renewable Energy

Renewable energy is energy from sources that do not deplete or can be replenished within a human lifetime. The main types of renewable energy are solar, wind, geothermal, and hydroelectric.[29]

It goes without saying that renewable sources of energy represent the answer to the problems caused by non-renewable energy resources, particularly fossil fuels. In a perfect world, we would be able to snap our fingers and instantly convert our entire energy-harnessing infrastructure to renewable energy. Even though we have started down that path to salvation, there are still incredible obstacles and challenges that are preventing an easy transition.

Regrettably, the transition from fossil fuels to renewable sources of energy has been glacially slow. Even though renewable energy resources were becoming available in the late 1970s and 1980s, renewable energy currently accounts for very little of the total global energy supply. Even in the United States, a country frequently recognized as a world leader and champion of renewables, only 9% of total energy production came from renewable sources as of 2011. That represents only a 1% increase since 1980, when renewables sourced 8% of the energy used by the U.S.[30]

Fossil fuels and other non-renewable resources continue to dominate energy production. There is room for optimism, however. Of all the renewable energy resources, solar and wind power are believed to be poised for significant expansion in the near future. Having evolved over the last four decades through a series of technological advances, solar and wind energy production are expected to achieve large-scale levels at lower price points than ever before. Additionally, there is a significant push to switch to 100% renewables and thus far 54 countries worldwide and eight U.S. states have required the transition.[31]

Solar

Solar energy is energy that comes from the sun. It is free, renewable, virtually limitless and has a low environmental impact. The sun delivers enough energy to the Earth in one hour to provide all the energy consumed by the entire human population in one year.[32] Solar energy does not produce air pollutants or carbon dioxide. However, solar energy does have limitations and inherent challenges. The amount of sunlight on Earth is not consistent, being dependent on location, time, season and weather conditions. The key to harnessing solar energy lies in capturing, storing and then distributing all of that energy. There are several types of solar energy, including solar thermal, solar photovoltaics and solar biomass.

Solar thermal utilizes the energy from the sun for heating or electricity production. Typically, there is an active system that utilizes "fans or pumps to circulate heat-carrying fluids."[33] Examples include swimming pool heating systems, which are often roof-mounted and circulate the pool water through the panels to heat them. There can also be passive systems which have no mechanical parts. Examples include heating or cooling systems that capture or reflect solar energy like a greenhouse or a solar oven. There are also high-temperature solar thermal systems that use mirrors to concentrate solar power (CSP) that are able to reach the temperatures necessary to create "steam which turns turbines, driving a generator to produce electricity."[34] Solar thermal power is low maintenance and emission free, but is susceptible to problems of intermittent sunshine and less-than-ideal location.

Solar photovoltaic (PV or solar cells) energy uses technology to convert sunlight into electric currents using semiconductors. When a photon from the sun hits the semiconductors (PV cells), usually made of silicon, electrons are freed. The layers of silicon in the PV cells are specially treated or doped with phosphorus, creating a positive charge, and with boron to create a negative charge. This doping allows the freed electrons to flow in one direction through the solar cell and generate an electric current. Metal plates on the sides of the PV cells collect the electrons and transfer them into wires where they can flow as electricity to power devices. An advantage to PV cells is that the electricity produced is scalable depending on how many cells are used. The semiconductor system can be set up to operate within the existing electrical grid or work independently.[35]

One problem inherent in solar power is the risk of storing large amounts of energy during peak solar production. In California, there has been a periodic overabundance of solar power. In order to avoid damaging its energy system from overload, the state has had to pay other states to take its excess power, shut off portions of its solar power collection or even pay its customers who generate solar energy to stop temporarily. "California has so much surplus electricity [from solar] that existing power plants run, on average, at slightly less than one-third of capacity. And some plants are being shuttered earlier than planned."[36] Recent technological advances in lithium ion battery storage methods have the potential to minimize or eliminate the problems inherent in solar energy peak generation or in a lack of generation at night or during cloudy days. Officials in Los Angeles, where these issues are most prevalent, have recently brokered an unprecedented deal to address the problem of solar storage with one of the world's largest battery manufacturers. Implementation will begin by hitting an expected overall solar energy source target of 7% of all electricity for the entire city by 2023.[37]

Solar biomass contains energy stored from the sun. It is organic material that comes from either plants or animals and it is a renewable source of energy. When biomass is burned, the chemical energy in biomass is released as heat. A common use of biomass is wood burning for heat. Agricultural crops, food and other biowaste can be burned as biofuels also. Ethanol is an example of a biofuel from crops of corn or sugar.

Wind

Wind energy has been used since ancient times to power sailboats and windmills. Over time, many innovations have expanded the number of applications of wind energy and increased its effectiveness.[38] The development of the United States was aided by wind-driven water pumps, cereal grinders and sawmills. Modern turbines harness the wind to generate electricity. “A traditional windmill captures the moving force of the wind - its kinetic energy - and transforms it into mechanical energy. In an electric turbine, the mechanical energy is further transformed by a generator into electricity.”[39]

The oil crisis of 1973 led to the wide development of wind farms. Wind farm expansion really began to pick up in the 2000s. In 2016, wind power surpassed hydroelectric as the leading source of renewable generating capacity. Wind energy has become more affordable in recent years, with prices having dropped 67% since 2009.[40] An ecological advantage to wind power is that it emits no CO_2. Land used by wind farms can also be used for agriculture or other simultaneous uses.

Despite these advances in expansion and affordability, wind energy comprises only 8% of total electricity generating capacity in the United States as of 2016.[41] Some disadvantages to wind power include noise pollution, unsightliness, structural vulnerability, difficulty of deploying heavy equipment and the variability of wind. Another hotly contested characteristic of wind energy generation is its threat to wildlife, particularly to birds whose flight paths are near the wind farms; however, in reality wind turbines kill fewer birds than cats and cell towers.[42] Another disadvantage to wind power can be that windmills take energy out of the wind or air. The air therefore cools and slows down as a result. This can create clouds under the right conditions and change local weather patterns.[43]

Hydroelectric

Water power (or hydropower) currently provides 16% of the world’s electricity.[44] Since hydropower relies on moving water to provide energy to turbines, power plants, dams and other energy-harnessing equipment must be located at or near water sources. Most of the hydroelectric plants or dams on land harness energy from rain runoff as it travels from high altitudes to sea-level in rivers and other waterways. Other sources of hydropower include waves at the shore and tidal currents.

In addition to being a renewable source of energy, hydropower has other advantages. Most hydroelectricity has low operating costs, particularly compared to other renewables. The potential supply of energy from water is vast. Typically, the infrastructure for hydropower serves multiple uses; in addition to turbine-driven electricity production, many sites feature agricultural irrigation, flood control, navigational optimization and even water recreation. CO_2 emissions from hydropower are very low, and it is widely available geographically.[45] All of these benefits have led to hydropower being one of the most widely utilized of all of the renewable energy resources.

Despite the number of advantages realized from harnessing energy from water, there are multiple challenges to expanding hydroelectric energy. Dams are a major component of the world's hydropower infrastructure, but they have increasingly come under fire due to their impact on the environment and on many communities of people who have been dispersed. In altering the natural flow of water and creating reservoirs or lakes, dams have caused the destruction or disruption of entire species and ecosystems. They have also led to the loss of culturally or anthropologically important sites. Many countries have established laws or policies that prevent or limit new dam construction.[46]

In addition to the negative ecological and social effects of dams, hydropower includes other drawbacks. Gathering energy from tides out in the ocean requires exposing expensive equipment to extremely stressful and damaging natural conditions. Hydropower is also vulnerable to climate change as the future behavior and nature of the oceans and land-based water are unpredictable.[47]

Geothermal

Geothermal energy is heat energy from within the Earth. Some geothermal energy is generated by tapping into water sources near the surface of the Earth such as hot springs or reservoirs. Other types of geothermal energy production requires drilling into the Earth. While hot spots in the Earth are ideal locations, other places can be used but incur greater cost and consequences. Geothermal energy has been used for heating buildings, food dehydration and milk pasteurizing.

The earliest known uses of geothermal energy date back to 10,000 BC, where it was used for cooking and bathing. The Romans built geothermal baths, today still located in the town of Bath, England. Geothermal energy has been used to heat homes and businesses while geothermal water has been used for medicinal purposes like treatment of high blood pressure and skin conditions. Geothermal energy was first used to generate electricity in Italy in 1904 and the first large-scale power plant in the U.S. began operation at the Geysers just north of San Francisco, CA in 1960.[48] Currently, the United States leads the world in geothermal energy production, "using 0.45% of total U.S. utility-scale electricity generation." Geothermal energy is most prevalent in the western United States, with California ranking number one in geothermal energy generation.[49]

The production of geothermal energy has several advantages. The process emits no CO_2. It is also one of the most reliable sources of renewable energy as it produces electricity regardless of weather conditions. In addition, geothermal power plants are compact in size compared to other structures typically used for different types of renewable energy.

A major downside of geothermal energy is its expense. There is a high initial facility setup cost, and drilling to reach the interior of the Earth is costly. Additionally, geothermal power plants can cause earthquakes with hydraulic fracturing. They are also very location specific and are only sustainable when reservoirs are properly managed with fluid being removed faster than replaced. Finally, greenhouse gases below the surface of the Earth can be emitted.[50]

Strategies

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5 E's

The unit will be taught utilizing the 5-E instructional model with the 5 E phases being Engage, Explore, Explain, Elaborate and Evaluate. The 5 E strategy is designed to trigger deeper student thinking through a more immersive, complex learning experience. In the Engage phase, students will start with an activity or demonstration that makes connections to their prior knowledge or life experiences. The hook of the unit will establish the focus of what students will be learning in the unit. In the Explore phase, students will explore a wide variety of unit content in different mediums related to climate change and global warming. Students will also conduct explorations on renewable energy sources in the Stations Lab. During the Explain phase, students will have opportunities to verbalize concepts they have been learning while the teacher provides definitions and explanations. This phase occurs at various points in the unit, especially when students perform the jigsaw activity about the greener home project. In the Evaluate phase, students will assess their understanding and have the teacher and peers evaluate concepts as well. The unit provides these opportunities when students evaluate their greener home project and when they compose their letter on climate change at the end of the unit.

Science Journals

Students keep science journals in my class. The journal serves as a tool for them to record key vocabulary and ideas. Students also draw out concepts they learn, and respond to thinking and writing prompts for think-pair-share discussions. The journal becomes a study guide and resource for students to utilize in the culminating project or summative assessment. The journal can also be used as a formative assessment evaluation tool for both students and teachers. Students will be using their Science journals frequently throughout my unit for the various activities, as well as note-taking and responses to writing prompts that activate critical thinking.

Student Dialogue

A big strategic focus in our district and school is structured student talk, or interactions where students engage in content through discussion using academic language. Our school's population is composed of a high percentage of English learners; practicing academic language through discourse is an excellent scaffold for ELL students. For all students, a best practice for learning is to be active participants rather than passive observers. In this unit, I plan to provide multiple opportunities for various types of structured student talk including think-pair-share throughout the unit, whip around at the end of lessons and jigsaw in the culminating project.

Think Pair Share

This is a strategy where students are asked to reflect on a question or topic. They are given some wait time to think. This can also be modified to include writing time so that students can write down their thoughts. Then students pair with a partner and take turns sharing their thoughts or their writing. This strategy empowers students to engage in shared learning with their peers.

Whip Around

Whip around is a closure activity in which students respond to a question about the unit content by writing it down. Students can stand up and then are called on randomly to share their answers. Students sit down once their answer has been shared. Once all answers are shared, the teacher can have a quick review of the material and correct any misunderstandings.

Jigsaw

The jigsaw teaching strategy is where students must depend on each other to succeed. Students must work independently on one piece of an assignment or project; each student becomes a specialized content expert and must “finish” that piece of the puzzle. The group then assembles all the pieces together to complete the jigsaw. Students must cooperate and learn from each other to complete the assignment.

Activities

Focusing on climate change, my unit will explore a multitude of global phenomena, including an increase in global temperatures and the shrinking of the polar ice caps, which are primarily caused by humanity’s past and current energy consumption practices. Managing and using energy resources will be key topics in my unit. Students will learn about the impacts and consequences of behaviors and actions taken by individuals when consuming energy. The unit will take approximately three weeks, with students meeting once per day for 55-minute periods.

In the opening of my unit, students will participate in an activity where they will simulate sea level rise. Using clay and water in two clear trays, students will create distinct sections of land with coastal cities and oceans. Ice cubes will be placed in one tray in an ocean area to represent sea ice. In another tray, ice cubes will be placed on land to represent land ice. As the class period progresses and the ice cubes melt, students will be asked to watch their trays and record data to see if the sea level rises and if there is water invading their cities. After discussing their findings, students will then view a map of nearby coastal cities Santa Cruz and San Francisco and discover how they will be affected by sea level rise. Then students will be shown their own city of San Jose. It will also be affected by global warming as water from the Bay will inundate our city. Students will then be asked to remember and discuss other disasters that have affected us locally and nationally. These events include severe droughts and water rationing throughout California, mudslides in the Santa Cruz Mountains, floods in the city of San Jose and wildfires in our state with corresponding air pollution in our valley as a result of those fires. Finally, students will be shown related videos and images while having the opportunity to explain their own personal experiences in the San Francisco Bay Area and California.

In the next part of the unit, students will be asked to document and assess their own energy consumption and impact on the environment by creating paper and Web models that represent their own Ecological Handprint and Carbon Footprint. A carbon footprint is the amount of carbon dioxide and other carbon compounds that are emitted by a particular person or community. An ecological footprint is the amount of land required to sustain a person’s or community’s use of natural resources. Various behaviors and actions generate a certain amount of resources used or carbon emitted. These include, but are not limited to, modes of transportation, types of food eaten and methods of electricity consumption. Our beliefs about conservation and the environment can have a major influence on the actions we take that determine our carbon and ecological footprints.

Education about energy and the environment have the power to change people's beliefs. It is the hope that by having students categorize their consumption of energy and other natural resources, as well as their attitudes and actions (or non-actions) toward conservation, they will become more cognizant of the consequences of their actions. Once students have an understanding of what type of impact they are having on the environment, they will analyze their behaviors and come up with ways to become greener citizens. We will revisit these student-generated ideas at the end of the unit.

In the middle part of my unit, I plan to hone in on one aspect of climate change: the rise of CO_2 levels in our atmosphere as a result of burning fossil fuels (coal, oil and natural gas), a major source of energy. We will analyze how increased CO_2 traps the sun's heat energy in the atmosphere, a process called the greenhouse effect. Global temperatures rise as a result, which can lead to many catastrophic events. To illustrate this rise in average temperature, students will be shown a time-lapse video that displays global values and colors representing temperature anomalies per year from 1880 to 2017 where almost all temperature variations in the 2000s are alarmingly red (hot).

As an activity to start off this exploration, students will be given a news article stating that the temperatures in a fictitious city have been heating up over the past 15 years and are continuing to rise. They will be informed that this trend is not just confined to their city but that it is happening globally. After being divided into discussion groups, students are each given a different article to read that contains one hypothesis of what might be causing this global trend. One of the hypothesis articles shows CO_2 levels taken from air bubbles preserved in ice core samples starting 420,000 years before the present day. Students will verbally share their hypothesis articles with the group. Together, students in the group determine which hypothesis is most plausible. They will then write a claim evidence and reasoning paragraph citing evidence from their chosen hypothesis article and reasoning from their group discussion. Afterwards, the Keeling Curve will be displayed with current atmospheric CO_2 levels. The Keeling Curve complements the most plausible hypothesis article. We will then conduct a class discussion where students take notes on why global warming is happening, primarily due to our use of fossil fuels and our insatiable need for energy. We will relate this back to sea level rise and the various other natural disasters being exacerbated by global warming.

In order to conceptualize CO_2, a gas, students will do an activity using bromothymol blue indicator to see the presence of CO_2 in a substance. Students will blow bubbles into a beaker of water and indicator mixture. The indicator will change from blue to green to yellow with the introduction of CO_2 from their breath. Students will also be shown a demo where CO_2 is created in a beaker with a simple reaction between baking soda and vinegar. The CO_2 gas will then be poured out of the container to extinguish a flame. Both of these activities will help students to visualize the presence of this invisible gas. This leads us into a discussion where students will learn where CO_2 gets recycled back into the environment and where it does not. To illustrate that CO_2 in the air and CO_2 in the water have different heat capacities, I will conduct a demonstration using balloons. A balloon filled with air will pop immediately when exposed to a heat source (in this case a lighter flame) and a balloon filled with water will take a much longer time to pop.

I will also discuss how mining for fossil fuels can also negatively impact our environment with a fossil fuel mining activity where students "mine" for chocolate chips using chocolate chip cookies. Students will also learn about air pollution with videos and a candle demonstration collecting soot.

At the end of my unit, students will research renewable energy sources such as solar, wind, geothermal and water in a jigsaw project. The goal is for students to recognize how these resources are better for the planet because they do not release CO_2 into the atmosphere. At the same time, we will explore the challenges involved in gathering and dispersing these renewable resources on a wide scale and analyze current solutions being developed.

As part of this culminating activity, students will design and then build a model of a green-energy home of the future that has a minimal carbon footprint and that utilizes the source of renewable energy most relevant to their given area. In groups, students will collaborate in class to make design decisions and illustrate the plan for their home as a paper blueprint or computerized visualization. Each group will be assigned a location in California for their future home where they can incorporate a nearby renewable energy resource. Sites include San Jose, which would be a good location for solar power, Livermore near the Altamont Pass, an area ideal for wind power, The Geysers, a geothermal location and Oroville, a location known for hydroelectric power.

After pitching their design plan and gaining approval to proceed, students will work together outside of school to build a physical model of their green home using materials of their choice. Once the models are complete, students will bring them to school and present them to the class.

At the end of the unit, students will revisit their carbon and ecological footprints and reflect on ways that they can mitigate the disastrous consequences of the heightened greenhouse effect. They will examine their families' current usage of fossil fuels and identify how they can practice greener methods of energy consumption while conserving energy resources. As an assessment, students will write a letter about climate change and energy conservation to family members or politicians and include what people can do to diminish negative effects using evidence covered throughout the unit.

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Teacher Resources

Global Warming Demonstration

www.jpl.nasa.gov/edu/teach/activity/global-warming-demonstration/

Why Melting Glaciers matter to coasts - a demonstration with land ice versus sea ice.

https://www.nps.gov/media/video/view.htm?id=2EAFFECC-E1F4-DF0B-5EB0EFF45020AECA

https://www.jpl.nasa.gov/edu/teach/activity/whats-causing-sea-level-rise-land-ice-vs-sea-ice/

Keeling Curve (Atmospheric CO2 at Mauna Loa)

https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

Lesson plan - What's causing temperatures to increase in the fictitious town of Solutionville and around the globe?

https://www.calacademy.org/educators/lesson-plans/the-heat-is-on-cause-and-effect-and-climate

Fossil Fuels: Chocolate Chip Mining Activity

https://www.calacademy.org/educators/lesson-plans/fossil-fuels-chocolate-chip-mining

Carbon Footprint and Ecological Handprint Handprints

http://climatechangeconnection.org/resources/climate-friendly-schools/resources-for-schools/

A map showing potential sea level rise

https://seeing.climatecentral.org/#9/37.3036/-122.0540?show=lockinAnimated&level=0&unit=feet&pois=hide

Look up your state to see what disasters your state is in danger of.

https://statesatrisk.org/california

An online footprint calculator that will tell you how many Earths it would take to sustain your needs if everyone lived like you.

https://www.footprintcalculator.org

Appendix

NGSS Standards

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

To work on this standard, students will be examining humans impact on their environment through our indirect and direct use of fossil fuels. They will then assess various sorts of solutions through the use of renewable energies (depending on factors such as location) that could minimize human impact.

MS-ESS3–5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

The students will examine various human activities primarily through their use of fossil fuels as well as natural processes such as volcanic eruptions that have led to a rise in global temperatures. Students will examine the Keeling Curve which graphs atmospheric CO_2 at Mauna Loa. They will also look at temperature data and various other data and graphs to examine this phenomenon.