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Solar and Wind and Batteries, Oh My!

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Introduction

"The path towards sustainable energy sources will be long and sometimes difficult. But America cannot resist this transition, we must lead it." – Barack Obama[1]

I consider myself a good teacher. Like other good teachers, I listen to and take suggestions from my coworkers. I then adapt these ideas to my purposes and make them fit my teaching style. Many a fine teacher has pontificated on the subject of giant hamster balls. You've seen the clear plastic balls that encase a rodent and tumble all about the room as the critter explores. In an educational setting, these balls would be enlarged to contain students. Usually the purpose is to keep a straight line, eliminate cases of hands-on behavior, or to just add order to the ebb and flow of the school day. I teach kindergarten. It's a bit like herding feral cats at times. Though not feral, my students possess vast amounts of energy, energy just waiting to be utilized. Kindergarten student plus giant hamster ball and some sort of turbine equals sustainable energy. If our president could tap into the bottomless energy reserves of five and six years old, America could be free of fossil fuels in no time. The solution to the global energy crisis lies in kindergarten. I actually believe this statement. Not so much in a kid-powered electrical grid, but the key to starting down Mr. Obama's path to sustainable energy is education. There is no better place to start educating students about energy sources than kindergarten. I will be starting that education in my own classroom with this unit.

My classroom is found at Kathleen Wilbur Elementary school in Bear, Delaware. Wilbur is a K-5 public school of almost 1,200 students. The school draws from a fairly wide stretch of communities in the Colonial School District of New Castle County in northern Delaware. Our 1,200 come from a variety of social and economic backgrounds. We are a title I school and 100% of our students receive free breakfast and lunch. Wilbur houses 9 kindergarten classrooms. They typically are populated with between 18 and 22 students. Last year my class consisted of 22 students: 9 females and 13 males. My class included students receiving English Language Learner (ELL) support, and speech services. In previous years, I have also taught students with Individualized Education Plans (IEPs) and behavioral plans in place. I would anticipate a similar class make-up in future years. As I do not anticipate Mr. Obama's path to sustainable energy being traveled by giant hamster balls, I'll focus on educating my kindergarteners on the subject of energy sciences.

Rationale

When I was five, I had virtually no concept of energy. My house was warm in the winter, cool in the summer. Mom could take cold food from the refrigerator and make it hot on the stove. With the turn of a knob, I could be entertained by Big Bird on channel 12. It was just the way my world worked. It's also the way my students' world works. Kindergarteners have no understanding of energy. The only time they would likely even consider what powers their world is when the lights go out. Honestly, aside from paying the electric bill or the gas pump, I expect most adults are very much like primary students in this thinking. So how do we begin to get people thinking? Do we go to the old dogs with our new tricks? Or do we begin by showing the puppies a new way of thinking about energy?

The Delaware Science Standards in kindergarten include a unit called *Push, Pull, and Go*. This is a favored unit of my students. It is their introduction to the topic of force. Throughout the lessons, students will experiment with rubber balls and K'nex building toys. They build slides, swings, and tops as they explore force and motion. Having witnessed the classes' passion for this unit, I thought to expand the unit and lay the groundwork for an understanding of energy sciences by enriching the curriculum with lessons designed to have the students making choices about sources of power. Due to the young age of my students, I have decided to focus on energy sources that they should easily understand: non-renewable (battery), solar, and wind.

Kindergarteners learn best when they are actively engaged in their learning. During this unit, students will design a series of Lego cars. Through these cars they will explore forces and motion. From past experience, I know that they will be excited to design and test their cars. Initially they will explore force and motion by pushing their cars. The lesson will be enriched by adding a power source for the vehicles. The class will explore battery-powered (non-renewable and can be compared to fossil fuels), solar-powered, and wind-powered cars. Students will ultimately design, test, and decide upon a final "ultimate" vehicle based on their learning.

I think it is important to mention that, within a few years, Delaware will be shifting away from the Delaware Science Standards and towards the Next Generation Science Standards. The new unit is entitled Force and Interactions. The content remains similar: a focus on the forces that act upon objects and the way that said objects respond to those forces. The difference between the standards is in our delivery of content. While Delaware calls for student observation, Next Generation requires students to conduct an investigation. This unit is designed to have students participating in the latter.

Another reason I have chosen to develop this unit is because I am a proponent of Science, Technology, Engineering, and Math, or STEM. STEM is a huge push in education right now. This push is not just coming from educators. Tim Sutherland the CEO of Pace Global Energy Services, a strategic energy consulting service, has expressed the need for STEM. "Our educational system is failing to stimulate interest and to excite our children to learn more about the sciences, engineering, and quantitative skills… America must do more to be competitive."[2] In this unit students design, build, test, and compare results to draw their own conclusions about sources of power. Mr. Sutherland advocates stimulating and exciting our students to problem solve, experiment, and think critically. This unit will have that effect in class.

Objectives

My first goal is to address Delaware Science Standards DE.1. This standard is called “Nature of Science and Technology” and it is all about scientific inquiry. It requires that students ask questions, collect evidence, form explanations, and then justify explanations using scientific knowledge. This sounds a lot like the scientific process, which students will be practicing as they decide which power source is best for meeting their goal.

A second goal of this unit is to engage the class in STEM learning. Throughout these lessons they will be creating machines, testing these machines, comparing their different machines, and ultimately choosing which machine they will use based on their findings. The lessons will be hands-on collaborations with a team of fellow students.

Rigor, Relevance, and Quad D. Wilbur Elementary uses the Rigor Relevance Framework as a way to raise higher level thinking skills within our students. Essentially the framework requires that tasks be rigorous which means moving up the Bloom’s Taxonomy chart and relevant to the kids which mean it is something with which they can relate. Quad D is where rigor and relevance come together to engage students in critical thinking. The following lessons will be rigorous and relevant to the students.

Content

Energy

Webster’s defines energy as the “capacity for doing work.”[3] Put simply, energy is what drives the world and everything in it. Energy is required to move a car from here to there, for a furry friend to wag its tail, for you to scratch your nose, and certainly for a young student to hamster ball from the classroom to the playground. Some tasks require a minimal amount of energy and others cannot be completed without great investments of energy. Energy comes in several forms. For a moment, I will focus on electrical energy as it is currently civilization’s favored child. Why do we love and depend on electricity so much? In his book *The Quest*, Daniel Yergin states the answer well, “Electricity delivers a precision unmatched by any other form of energy; it is also almost infinitely versatile in how it can be used.”[4] As beloved as electricity is, it is certainly taken for granted. Flip a switch, electricity makes things work. Flip a switch again, things stop working and electricity waits patiently until we need it again while we give it not a second thought.

The first switch was flipped on September 4, 1882. Thomas Edison flipped that switch in a dim room and J.P. Morgan’s office was flooded with light. Concurrently, bulbs in the offices of the *New York Times* were also alit. With that flip of a switch “the age of electricity had begun.”[5] Edison’s version of electricity wasn’t without flaws. This electricity was direct current. Sadly, because of its low voltage it could not be carried very far. It took the ingenuity of Nikola Tesla and the savvy of George Westinghouse to come up with alternating current, which could be amped up to a much higher voltage and then sent through wires over much greater distances before having the voltage lowered again for safe usage. The final piece of the electricity puzzle was put in place by Samuel Insull. Insull found a way to sell electricity not by the bulb, but by a customer’s usage. This distinction helped get electricity into the homes of average citizens and secured its place in those homes and our history.

The recipe for electricity is pretty simple; “magnets plus copper wire plus motion equals electric current.”[6] The not so simple part is getting that motion piece. Traditionally, we have burned fossil fuels to make much of our electricity. There are many other ways to create our electrical energy. We can use solar power, wind power, hydro power, geothermal power, biofuels, and nuclear power to generate our required electricity. To prepare for this unit, I have learned much about these varying sources of energy. But, before I get too into my new found knowledge, it would be wise to acknowledge that energy comes at a cost, and it is not always just a cost in dollars and cents.

Energy or Climate; A Crisis is Still a Crisis

People consume energy. Though I suppose to be more accurate, in addition to just us, our stuff consumes energy as well. We use energy to make things hot, to make things cold, to move short distances, to move long distances, to make things brighter, and to feed our bodies. Our stuff also consumes energy in the process of making more stuff. That seems like a lot of energy being used. Also consider that the current population of the United States is about 323,900,000 people.[7] That means that hundreds of millions of Americans are adjusting the temperature in their homes, driving or riding somewhere, heating up dinner, refrigerating their leftovers, and turning night to day with the flip of a light switch. There’s our pursuit of stuff too; televisions, computers, cell phones, video games, and hair dryers all consume energy. Of course energy is also being consumed in the process of manufacturing these things, as well as clothing, books, toothbrushes, flower pots, cans of Spam and anything else of which you can think. That’s lots and lots of energy. Where does all that power come from? 81% of America’s power comes from fossil fuels.[8] A lump of coal, which is a fossil fuel, likely once would have been an ancient flower or tree, it could possibly have been a fish from long ago, or even a dinosaur. Here’s the rub. Fossil fuels take a very long time to develop. They are not exactly finite, but we are sure using lots of them faster than they can be replenished. In 1977, then President Jimmy Carter announced an “energy crisis”. He urged that “We simply must balance our demand for energy with our rapidly shrinking resources.”[9] Things have changed since Carter’s day. Remember, today 81% of our energy comes from this “rapidly shrinking resource”, in 1977, 75% of our energy was from fossil fuels.[10] The numbers seem to indicate that in the roughly 40 years since Carter’s call to change our energy habits we have actually increased our dependence on fossil fuels by 6% of our total energy usage. Looking at these numbers seems bleak. However in the past 40 years new technology has also developed that allows us to access much more fossil fuel than was available in the 70’s. Will we ever run out of fossil fuels? Seminar Leader Brudvig expresses his answer simply. We will never run out of fossil fuels. He points out that the amount of fossil fuels is linked to the percentage of oxygen in our atmosphere through the process of photosynthesis. Mathematically, if our oxygen level dips, so to do our fossil fuel supplies. Our oxygen level in the atmosphere, even after 100 years of burning fossil fuels, has not significantly diminished. Therefore, we haven’t scratched the surface of our fossil fuel supplies yet. Yippee! Go gas up the minivan. Brudvig also states that before we could ever use up our fossil fuels we will have ruined our environment. Wait! What?

The Earth is surrounded by a “blanket” that protects us and helps make us comfortable. This “blanket” is the atmosphere. The atmosphere “separates us from the emptiness of outer space”[11] and shields us from harmful levels of light from the sun. This atmosphere is made up of several differing components in particular ratios, a lot like a recipe. The major ingredients are oxygen and nitrogen but there are additional components like carbon dioxide, methane and other so called greenhouse gases. These greenhouse gases are needed to keep the recipe balanced, but they are in much smaller quantities. The atmosphere and the biosphere (the living part of the Earth) maintain an easy balance and the recipe remains mostly unchanged over time. At least it did until the burning of fossil fuels became a cheap and easy way to meet our growing thirst for energy. As fossil fuels burn, they release carbon dioxide into the atmosphere. This addition to the recipe upsets the delicate balance between the bio and atmosphere. Unfortunately, the burning of the fossil fuels continues and the change to the atmospheric recipe becomes greater and greater. This change has had consequences. These changes lumped together are called climate change. In the case of climate, change is bad.

It is useful to keep in mind that the recipe for atmosphere calls for its components to be present in specific ratios. With the burning of fossil fuels, the level of carbon dioxide is rising. Carbon dioxide is measured in parts per million (ppm) which means comparing the amount of carbon dioxide to the total volume of the atmosphere. In January of 2005 the carbon dioxide level was 378.21 ppm. By June of 2016 the measurement was 404.48 ppm.[12] That really doesn't seem like all that much of a difference but let's examine some data that correspond to the increase. Since 1880 the average temperature of the Earth has been raised by 1.4°F. I know less than two degrees seems pretty insignificant. The weather can fluctuate by many times that amount from day to day. That is true, but that is weather. It does fluctuate. Climate is not meant to shift about like that without bringing drastic change. In fact Yergin has said "A rise of just two or three degrees in the average temperature, it is feared, is all that is required to wreak havoc."[13]

But what exactly does havoc look like. The north and south poles are covered with ice caps and glaciers. This ice contains 68.7% of all of Earth's freshwater supply[14] . They are shrinking. In 1979 there were 7.19 million sq. km of arctic sea ice. In 2015 there were 4.63 million sq. km.[15] Those measurements show a loss of nearly 2 ½ million sq. km of ice. The amount of ice does fluctuate from season to season and year to year, but those numbers mark a significant difference. To bring this number into clearer focus 2 ½ million sq. km of ice disappearing is like melting 3 ice cubes the size of Texas. Try to remember that the average temperature of Earth has only been raised by 1.4°F. We only have about 6 Texases worth of Ice Cap left. Imagine how many more Texases we would lose if the temperature keeps getting hotter.

Ever wonder where all that melted ice is going? It doesn't just disappear. It goes into the oceans. The oceans are huge, but every drop raises the oceans' levels. Over the past 100 years the oceans have risen almost 7 inches.[16] This is a problem, but it could get much worse. "Scientists expect roughly 2 to 7 more feet of sea level rise this century – a lot depending upon how much more heat-trapping pollution humanity puts into the sky."[17] If we continue to add carbon dioxide to the atmosphere at our current rate or an elevated rate, we will risk up to 7 feet of sea level rise. Consider Hurricane Katrina and Hurricane Sandy. Katrina devastated New Orleans, Louisiana. It is estimated that the hurricane cost 125 billion dollars in damages to the area.[18] Another 65 billion dollars of damage were caused by Hurricane Sandy when it hit the northeastern sea board, mostly New Jersey.[19] Both areas heavily affected by these storms are low lying areas. They can ill afford to risk another hurricane when paired with the rising sea level. Another way to look at is, if you don't currently own the much coveted ocean front property, maybe someday you will. But don't start buying up land in central New Jersey just yet. Fossil fuels are just one form of energy. There are several choices available to us energy consumers.

Non-Renewable Energy Sources

Fossil Fuels

Most fossil fuels come from the Carboniferous Period. This was a time hundreds of millions of year before the dinosaurs. The land was very swampy and full of trees, ferns, and leafy plants. When these plants died they sank to the bottom of the waters. Over time the remnants were covered over by peat, clay, and minerals. As the years piled more material atop the remnants, the pressure squeezed the material and it turned into what we call fossil fuels. There are three main types of fossil fuels. They are coal, oil, and natural gas. As stated above, 81% of America's fuel demands are met by fossil fuels. Of the three major types, oil is currently king, followed by coal, and then natural gas. The fuel we cherish so much was mostly plant-life over 300 million years ago. Needless to say it takes far longer for fossil fuels to form than it takes for us to mine them, refine them, and use them up. Because of this fact, they have been termed non-renewable. Non-renewable energy is not sustainable. Another issue with fossil fuels is that they must be mined. The mining process is frequently very damaging to the surrounding environment and the ecosystem. Because of the lack of sustainability, the environmental concerns from procuring the fuel, and the climate issues spoken of earlier, fossil fuels are generally not considered to be the best choice for supplying our energy. Why then does 81% of our energy come from fossil fuels? The answer is economic. Coal costs between 1 and 4 cents per kW/hr. Natural gas comes in at about 2.3 to 5 cents per kW/hr. Oil costs between 6 and 8 cents per kW/hr.[20] Economically speaking, the fossil fuels are competitive or way cheaper than sustainable options.

Nuclear Energy

Another non-sustainable energy choice is nuclear power. There are two types of nuclear energy. Fission is our first option, and the method we are currently using for nuclear power. Basically, we split nuclei of uranium (very heavy nuclei) to release energy which we can then use. Our second option is nuclear fusion. Fusion fuses light nuclei (hydrogen for example) together and also releases energy.[21] In principle, this energy could then be used to create electricity, but a method to harness nuclear fusion energy does not yet exist and will be many years in the future if at all possible. One major advantage of nuclear power has over our typical fuels is that "the nuclear energy available per atom is roughly one million times bigger".[22] One million times the energy sounds fantastic. In fact, it sounds like our problems could be solved, except nuclear has some problems of its own.

The process of nuclear fission generates enormous amounts of heat. To cool to a nuclear reactor, a large amount of coolant must be applied. On March 28, 1979 Three Mile Island in Pennsylvania experienced a problem. A chain of events which included turning off the reactor coolant and a partial meltdown led to the venting of a minor amount of radioactive steam. After investigation, part of the failure was attributed to human error. This series of events led to panic in America. It also led to a braking of the progress of nuclear power in the USA.

April 26, 1989. Chernobyl, Ukraine. A series of events led to explosions and a fire at a nuclear power plant. Unlike Three Mile Island, this meltdown released massive clouds of radioactivity across vast stretches of Europe. Once again, part of the issue was attributed to human error. After this accident, much of Europe reacted similarly to the United States following the problem in Pennsylvania.

Japan also experienced a nuclear nightmare. On March 11, 2011 the nation was rocked by a powerful earthquake. The Fukushima Daiichi plant suffered little damage from the massive quake. However, a tsunami of unprecedented size followed. On account of the two natural disasters, the station was shut down, and the backup generators were swamped and rendered useless. The all-important coolant stopped flowing. The following weeks were filled with explosions, panicked evacuations, a complete plant shutdown, and another big black eye for nuclear power.

In addition to the higher energy yield of nuclear there are some other advantages. The greatest advantage is that it is free of carbon emissions. This could solve the climate change problem. Nuclear waste is also a tiny fraction of the size of fossil fuel waste, although that waste remains radioactive and requires special care to store safely. At about 6 to 7 cents per kW/hr, nuclear power is also comparable in price to petroleum. There is even some speculation that nuclear power could become sustainable if we could affordably extract resources from the ocean.[23]

Is nuclear a viable option? That depends on your beliefs. If you believe that human error is unlikely to lead to another nuclear crisis and that natural disasters of unprecedented magnitude probably won't occur again then nuclear must look pretty good. If you would be concerned about these things nuclear could be a scary proposition.

Renewables

Solar Energy

Solar power is energy derived from the Sun. It is limitless and exceedingly powerful. It's the reason we wear sunscreen, don't lock our children or pets in the car during the summer months, and step lively when we cross the sand at the beach. Sunlight is why our plants grow and flourish and why our teachers and moms told us not to stare right at our star. Sunshine is also free. It is powerful enough to meet all of our energy needs. So why is it not our favored option. There are some major problems that need to be overcome if solar is to be the answer to our prayers. One challenge that is not insignificant is night. For that matter cloudy days are a bit of an issue as well. No sunshine traditionally has meant no solar power. Also how do we channel the power of our star to do what we require it to do? We can't exactly run an extension cord up there and plug in. To begin thinking about these challenges it could be helpful to first consider the different energy options that can take advantage of the Sun's rays.

Natural Photosynthesis is the process by which plants transform sunlight into sugar, or in their world, food. Plants need certain things to live and grow. Sunlight, water, and carbon dioxide are among those things. Additionally, plants need soil, but that's only to hold them steady and secure so it has little to do with photosynthesis. In simplistic terms here's how photosynthesis works; plants take in carbon dioxide out of the air (this is a really good thing). They also absorb water through their root systems. Enzymes found within the plant break the water into its components of hydrogen and oxygen. When sunlight strikes the plants it sets off a chain of events. The chlorophyll (green pigment) in the leaves reacts to the sunlight and elevates an electron (negatively charged particle) in the chlorophyll causing unbalanced charges within the system. This unbalance of charges drives the formation of sugar which includes the carbon dioxide from the atmosphere. The oxygen from the water is released to the atmosphere and the sugar is used for the plant to grow and flourish. This removing of carbon dioxide from the air and releasing of oxygen in its place is how the atmosphere stayed in balance for so many millions of years. Natural photosynthesis is an amazing process. However, we can't plug our TV into a cypress tree and be entertained. Though, it may be entertaining to watch someone try. Natural photosynthesis did inspire some scientific research into ways we can "plug into sunlight".

Scientists are currently exploring the idea of artificial photosynthesis. They are trying to emulate the process of breaking the water molecule and exciting the electrons with sunlight. Their end result is not the creation of sugar, but the creation of usable fuel. This is an ongoing process and at present seems far from being a viable option for meeting our power needs.

Photovoltaic cells (PV cells) are a part of our energy reality at present. They can convert sunlight into electrical power. They work by exciting electrons and causing a reaction similar to photosynthesis. The sun hits the solar panel which elevates an electron. It causes a lack of balance and the electrons move. The movement of the electrons through the system results in usable electricity. We can plug a solar cell into an electrical device and off we go. One advantageous thing about PV cells is that they are scalable. If you want to power a home, put on enough cells to produce the electricity that you require. If you want to power a factory, put on additional cells and it can be done. Another advantage with PV, is that it can work in conjunction with the current electrical grid, or PV can work independently. PV cells can power a well or generator in remote locations far off the electrical grid. It can also provide a portion of a building's power while still allowing electricity from a local provider to supply the rest. In some cases, energy drawn from a PV cell can even be sold back to the local energy provider in the case of a surplus. PVs seem to be the answer to our energy problems. Like our other energy sources, PVs are not without their shortcomings. They are not terribly efficient. They can create electrical power but they are only operating at about 15% efficiency. That leaves much energy that is slipping away. They are also very costly. They are expensive to purchase and install. Solar energy can cost between 25 to 50 cents per kW/h.[24] That is far greater than what fossil fuels are going for today.

Another way to utilize the power of the Sun is through passive solar energy. This is converting the energy of sunlight into thermal (heat) energy. The sun does this all by itself. In the midst of a summer heatwave, it is common to see the local weatherman on the news frying an egg on the blacktop. Concentrating solar power (CSP) systems operate off of this idea. They concentrate light to create heat. The energy can then be used to heat a substance like water to turn a turbine and create electricity.

Solar energy is the promise of harnessing the power of the Sun. Yet today it accounts for only 0.5% of America's total energy usage.[25] The future appears promising for solar though as "the whole weight of the industry is concentrated on that single goal – bring costs down further."[26]

Wind Power

"Outside of hydropower, wind has been by far the most successful renewable electricity source".[27] Wind is another power source that nature provides free of charge. It can be extremely powerful and if captured can provide a significant amount of power. Windmills are the typical manner in which wind is channeled to do society's work. In the past, windmills have used mechanical energy to complete tasks such as the milling of flour. The blades on a windmill are turned by wind power. They are connected to a turbine which can transform that mechanical energy into electricity. That electricity can then be distributed to consumers. Wind can be powerful and compared to solar energy quite inexpensive, about 5 to 7 cents per kW/h.[28] At that price point, wind is even comparable to fossil fuels. However, like solar energy the wind also suffers from intermittency. Its not always blowing. When it doesn't spin the turbine, it doesn't generate electricity. There is also to date not a viable way to store excess power from very windy days and save it for a day of stillness. The other problem with wind power is that it is not a viable form of power for all areas. There are certainly locations prone to strong wind, but there are many spots where wind is weak. Unlike solar which is fairly easily scalable, wind lends itself to land generator sites. The higher the windmill, the more power it can generate. For an individual home, a smaller scale generator will not be as effective. In 2015, 4.7% of the electricity in the United States was generated from the wind.[29] In the states of Iowa and South Dakota, where strong winds are prevalent, in excess of 25% of electricity generated comes from the wind.[30]

Other Options

There are other sources of energy that are worth noting, though they will not be a focus in this unit. Geothermal energy taps into the heat below the surface of the Earth to generate electricity. Much like wind power, location dictates the viability of geothermal electricity production. Tapping into the ebb and flow of the Oceans' tides can also lend itself to the generation of electricity. Naturally, this form of power is only viable in select locations with access to the waves. Similar to the tides, moving water in the form of rivers can generate significant energy. Also similar to the tides this river-based hydroelectric power is all about location. Hydroelectric power is also one of the oldest and most successful of renewable resources. Long ago mills were established along rivers and large streams as a way to grind flour, or in a case close to home in Delaware, gunpowder. Hydroelectric is viable, but not for everyone.

Hydroelectric may be one of the oldest renewable fuels but using biomass has to be the oldest of humanity's tricks. Biomass refers to once living materials that are burned for heat. "Wood as the old saying goes, warms two times: when you cut it and when you burn it."[31] The fire ring is a part of our ancestral past. It is also part of our present. Throughout the world the burning of biomass for heat is still very prevalent. Personally, I can attest to this as my home is solely heated by the burning of biomass (wood pellets). Yet in the recent past there has been much success in transforming biomass into biofuel. Ethanol is a biofuel that is made in the United States by transforming corn starch into fuel. This ethanol can power an automobile though it is usually mixed with petroleum-based gasoline. In Brazil, sugar cane is transformed into ethanol and by 2006 around 30% of its total energy was derived from biofuel.[32]

There are many forms of energy. Non-renewable sources are the king of the hill right now, but they are not sustainable. Barring game-changing technological innovation, society will need to look to renewable energy as we power up our devices, drive our cars, or fly our planes into the future.

Learning Strategies

Science, Technology, Engineering, and Math (STEM)

A strategy for initiating a STEM activity is to provide some supplies, set a goal for the students, and let them create. A big part of STEM learning involves trial and error, and error, and error, and finally success. My students will be going through this process multiple times during the unit. As I will likely be using this unit in late winter or spring, my students will have had much experience getting past an initial failure.

Hands-on Learning

All students, most especially those in the primary grades, learn best by getting their hands dirty. This type of learning raises the level of engagement and also lowers the level of off-task and counterproductive behavior.

Collaborative Learning

During this unit, the students will be working in teams. This sort of learning does pose some challenges. For example, how do I assure that all students are participating and engaged? How do I guarantee that all students assist with all aspects of the activity from set up to clean up? One benefit of a STEM learning approach is that I, as the teacher, am free to float about the room and coach as I see fit. It also allows me to monitor closely the activities of each group and intervene if necessary.

Compare and Contrast

We will be using a series of T-charts to record our ideas about benefits and drawbacks from the different sources of energy that we explore. These charts will allow easy decisions to be made when our teams must choose our preferred power source.

Rigor/Relevance Framework and Quad D

Essentially, rigor means a high level of critical thinking and relevance means that the students can connect to the content. The framework is designed with four levels in mind. They are labeled quads A through D. Activities which fall low on the Bloom's Taxonomy chart and feature content that is not personally relatable to the student belong in Quad A. Quad B includes activities that require low levels of critical thinking but are easily connected to students. Quad C bumps up the level of critical thinking but again may be difficult to connect to for students. We at Wilbur aspire to teach in Quad D. Quad D requires high level critical thinking and is also easy for the students to feel a connection. I am designing my activities to push students to work within Quad D.

Class Activities

Activity One – An Introduction

I will assign students to a collaborative team. The teams will contain four members (if numbers allow, otherwise teams of three would work as well). We start by reviewing what we have learned of force and motion. In a previous science lesson, students have used balls to explore the idea that a big push makes for quick motion and a little push makes for slower motion. I would lead the discussion to arrive at this information. Once our experience with the rolling balls is fresh in mind I will introduce our next challenge. Teams will be responsible for using Legos to build a car. They will then repeat the rolling ball experiment with the Lego vehicles. Spreading out in the work area or hallway outside our class, teams will sit in a square (or a triangle) about ten feet apart from each other. They will take turns rolling their car between team members. After all teams have had sufficient time to roll their cars I will have them gather materials and meet on the carpet for a discussion. We will review our findings about force and motion. I will be looking for students to share the idea that forces (pushes) can be large or small and that the size of a push relates to the speed of motion. I will then ask them if they know any vehicles in the "real world" that move. As they share ideas, I will record their responses on the board. I would anticipate that they will come up with cars, trucks, buses, planes, boats, motorcycles, and other common vehicle types as answers. I will ask if we have to push these vehicles to get them into motion. I will take a few responses to the question, but at this point I will wrap up activity one.

There are a few things to consider regarding this activity. Firstly, Legos can be expensive. I am fortunate to have a large supply of them in my classroom. I did not always have these tools. I was able to receive funding through DonorsChoose which paid for my Legos as well as other supplies. I would encourage anyone to look into DonorsChoose or GoFundMe as a possible source of funding to support ideas such as these activities. The time it takes to build these cars will vary greatly from team to team. Allow enough time for slower paced builders to complete the challenge and enjoy the rolling of the cars. To keep the quicker builders engaged, I will challenge them to change their car to make it bigger, smaller, or “cooler”. This will extend the activity and allow me to keep all groups together.

I would also like to share how I distribute the Legos. I create ziplock gallon bags full of Lego pieces. I make sure that included are necessary pieces like wheels and axles. I always give them more Legos than they actually need. The spare pieces allow for student creativity when building. Each team will have different cars and that is just fine. The extra pieces may also lead them to discoveries as they explore. For example, a team could grow to learn that the fewer pieces they use for their car, the faster the vehicle may travel.

I feel that this is a good first activity. It allows the teams to collaborate while figuring out a successful car design. This will make the upcoming lessons a little easier. It is also an engaging way to allow for observation of team dynamics. During this activity, I will be free to float from group to group and notice teammates who are doing a great job of sharing, taking turns, and being supportive. I can then praise these choices and deter choices that may not be what I am hoping for. By leaving my closing question hanging, I hope to keep them wondering about the answer and it gives me a good place to begin activity two.

Activity Two – Wind Power

To begin this activity, I will review our list of vehicles and draw attention to or add to the list a sailboat. I will then ask if we would have to push a sailboat. When the class responds that we would not, we will discuss what provides the push for a sailboat. After the class has agreed that the wind pushes the sailboat into motion, I will share a story about the wind. There are many choices for a story featuring wind. If you have a book about sailing, windmills, or kites that would work very well. It all depends on what resources you may have access to. I will be reading Winnie the Pooh and the Blustery Day which my previous classes have greatly enjoyed. After the story, we will discuss the power of the wind as a force. I will then challenge the class.

For this challenge, students will be returning to their Lego bags and cars from activity one. Prior to class, I will add to the bags some construction paper and scotch tape. This challenge will be to adapt the team car (or disassemble it and start over) to make it wind powered. The ground rules for this challenge will be to move the car a distance of no less than ten feet without physically touching the car. Teams will then collaborate to create a wind-driven vehicle. Similar to activity one, student creativity will come into play. No two wind cars will be alike (although once a group is successful, other groups may borrow their ideas). Students will also likely have to overcome failures in this activity. Some cars will tip over when blown. Some will just not go. Some groups will struggle to reach the goal. Trial and error is a component of STEM learning. My students will be encouraged to not give up and continue trying different car designs until they succeed. Even if a group is struggling mightily, they will have the benefit of seeing other groups in action and this should give them a hint as to how to proceed. To extend the activity for early finishers, I would invite them to use crayons to decorate their sail or challenge them to again tweak their car to make it better. Once all teams have succeeded in the challenge, I will again have them clean up and meet on the carpet for discussion.

I will begin the discussion by asking what problems might come along with a wind car. Possible answers are that if the wind doesn’t blow, the car doesn’t go or if the wind doesn’t hit the sail right it doesn’t work well. As the class shares ideas, I will record them on a T-chart. To make this chart, I will fold a paper in half, write wind across the top, and then head one column with a smiley face and the other with a frowning face. Under the frowning face, I’ll record class answers about the disadvantages of wind power. I will then ask what are good things about a wind-powered car. Answers could possibly be when the wind is strong the car goes really fast. I also anticipate that this column will be incomplete until activity five.

Activity Three – Battery Powered (Non-renewable)

I believe most administrations (my own included) would frown on bringing gasoline into any classroom, much less a room inhabited by five and six year olds. Yet most of the vehicles in the real world are powered by some form of gas. To begin this activity, I will ask the class about cars, buses, and trucks. Specifically, I will ask about what powers these forms of transportation. Many students will know from experience that gas has to be pumped into the car. This would be a good time to share a book about fossil fuels. I will use one called “What’s So Bad About Gasoline: Fossil Fuels and What They Do” by Ann Rockwell. After the story, I’ll circle our talk back to cars with a question about what happens when your car runs out of gas. This will probably elicit a response of the car stops or you have to get more gas. I will then explain that we cannot use gas for our Lego cars but is there a good substitute. A good way to get the students to come up with the answer of batteries would be to ask about powered toys. Once students have agreed that batteries would work, I will draw parallels between nonrenewable gas and nonrenewable batteries. The stage is now set for our next challenge.

Build a battery-powered Lego car that can travel at least ten feet without a physical push. As in the previous activities, students will work together to successfully build this vehicle. This will be challenging. I will include a Lego +Power Functions motor and battery box in each group’s supplies. These can be difficult to attach to the wheels of a Lego car. I will provide my students with a premade sample that will allow them to see how to attach these specialized Lego pieces. I could also include a photocopy of the instructions for how to connect these pieces. As in the prior activities, students will collaborate in the making and testing of a Lego car. When all teams are finished, we will regroup for a check in on the carpet.

Like we did for the wind-powered car, we will now fill in a T-chart for the advantages and disadvantages of the nonrenewable energy source. Also like our previous T-chart, the students will most likely not completely fill in the chart until later on.

Activity Four – Solar Powered

Start this activity with the reading of a book that ties to solar power or the sun. I will be reading “Curious George Discovers the Sun”. This book explores solar panels and solar power. After reading the book, I will ask the students about George’s adventure and the solar panels he encountered. I will then ask the students what they would need to make a solar car. Once they answer with solar panels, I will unveil our next challenge. Create a solar-powered car that can travel no less than 10 feet. It should be noted that our solar cars will require bright light or a sunny day to function. I will be making sure that the weather conditions look promising the day I run this activity. That being said, I would also take a car out on a cloudy day to demonstrate what happens when the sun isn’t strong in the sky. The kids would benefit to see this too.

For this activity, I will not be using Legos. Instead I have purchased solar car kits. There are many available that are relatively inexpensive. Again, consider writing a grant; they’re not too much trouble and could get your projects funded. This activity will be a little more structured than the previous car-building experiences. I will give the students step by step instructions on how to construct their car. I don’t anticipate a great deal of difficulty putting these cars together (they’re really fairly simple), but the students are not familiar with these materials so the extra level of support will be greatly beneficial. Once our cars are constructed, we will go out to our bus court (this is a very low traffic zone at my school outside of arrival and dismissal times). Students will sit in their squares or triangles and send the cars back and forth between them. It would also be good to challenge the kids to cover the solar panel with their hand to see what happens. Spoiler alert, the wheels stop going.

Once the cars are collected we will reconvene on the carpet and complete our third T-chart. Again, they will be able to add items to their chart in activity five also.

Activity Five – Ultimate Car

This is our culminating activity. We will start on the carpet and review our T-charts. Having experienced three different energy sources, the students (with guidance) should be able to add some items to said charts. For example, they may now appreciate that the battery (nonrenewable) will operate in any form of weather. It does not depend on sunshine or wind. They may also relate that batteries need to be replaced, but solar and wind power don't. I would also guide them to recognize that when a battery is done we have "trash" left over, the dead battery. Solar and wind power do not leave "trash" behind. Then I'll introduce that we have one more item to consider for our charts.

Economics. In social studies class, we learn about money and making choices. Teams will need to make a choice now. Each team will receive ten fluffy balls. These will represent money to purchase the materials for their ultimate car. They could purchase the supplies for a solar car for eight of their fluffies. Or, they could purchase supplies for a sail car for eight fluffies as well. The battery-powered car supplies will only cost two fluffies up front, but they will need to pay one extra fluffy every time they drive their car. I'll tell them its like when mom or dad has to pay to put gas in the tank. We can then add to our charts that renewable energy sources like wind and solar have a pretty high start up cost. Nonrenewable energy (batteries/gasoline) are pretty cheap to start but you must keep paying and paying.

Our challenge this time is to get the car to travel no less than twenty feet without a physical push. The longer distance really doesn't matter to me or our learning but the kids will get very excited about this perceived larger challenge. Give the teams thinking and discussion time to decide which car they would like to purchase. They will then trade in their fluffies, get their car supplies, and get building. By this point in the unit, I would anticipate that students will successfully construct a car and meet the challenge. Then, we will return to the carpet and have a final discussion.

Teams will have a few minutes to get their thoughts together. Then, they will get up in front of the class. Show off their "ultimate car" and using ideas from our discussions and T-charts explain why they choose that energy source for their vehicle. This is the Quad D, higher level thinking, part of our lesson. It is rigorous because the students must justify their choice with facts taken from their learning. It is also relevant because they are sharing information about their car, that they chose, they tested, and they built.

Appendix

Common Core State Standards

CCSS.ELA-LITERACY.SL.K.6: Speak audibly and express thoughts, feelings, and ideas clearly.

Delaware Science Standards

Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying the explanation.

Next Generation Science Standards

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

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This is a great book which examines our dependence on fossil fuels. It is well written in a narrative format yet is loaded with history and facts. Very good background knowledge.

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