Marcellus Shale: Finding Common Ground

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Unit Index:

Overview:

This curriculum is centered on the controversial topic of the natural gas from the Marcellus Shale. It is designed for students in their middle school years but can be adjusted to suit the needs of any level of education. The topic can be connected across many educational disciplines particularly focusing on the social, political, and economic impact that the extraction of this resource could have on the northeast region of the United States. While it may be, that the people most affected by this discovery will be in the proximity of the northeastern part of the United States, its affects will not be limited to this region. Consequently the unit can be expanded to observe the trickle affect the resource could have on the entire country. The overarching theme of the unit is to create awareness and inspire students to become active stewards in creating sustainable change regarding the Marcellus Shale Formation. The unit will last for approximately five weeks; however some aspects of the unit can be omitted or altered to obtain the desired result. In order to link the core standards with the Marcellus curriculum, students will participate in this unit during the fall term where landforms and their various characteristics are taught. Thus, this unit will include a strong focus on the geology of the Marcellus Shale and how it relates to everyday life.

To accomplish these objectives the unit will employ activities that provide the students with opportunities to "learn by doing," rather than the usual rhetoric most often utilized. The unit starts by introducing the students to the common structures of the Earth. This includes an introduction to the Rock Cycle and the processes that create many of the resources used today. Once this concept is grasped, students will progress and identify how organisms from around the world benefit from the earth's processes. Much of the focus during this section will be on how humans exploit fossil fuels and are depleting many of the resources that took millions of years to create. When this section of the unit is completed, the students will have understood how fossil fuels are created and how utilized throughout our world. This will prepare the students for the next stage of the unit, which focuses on the Marcellus Shale specifically.

At this point the students will have received enough background information regarding the Earth and its processes to move forward and gain a deep understanding of the impact of the Marcellus Shale. Therefore, they will begin to identify the current controversy behind Marcellus

Shale and what all the fuss is about. There will also be a particular focus on "fracking," the contentious process used to extract the Marcellus Shale gas from the Earth. In addition, they will look into the impact the drilling is having on the environment and what is being said about the resource around the area. One particular aspect of the environment that is ominously discussed regards the effect that "fracking" has on the groundwater in the area. Evidently, this affects everyone in Philadelphia, since our drinking water is directly tied to the groundwater from the drilling area of northeast Pennsylvania. With that in mind, the students will investigate into the potential impact contaminated drinking water could have on northeast Pennsylvania as well as the surrounding area. To conclude the unit, the students will have to take into consideration all that they have learned and present a point/counterpoint argument for the Marcellus Shale drilling. To completely understand how to make the argument they must first understand what the "argument of authority" is. The students will start by analyzing the sources of their information. Then they will gain a clearer picture of the situation and make strong arguments about any topic related to the Marcellus Shale. Because the argument made will be their own, students will have amplified confidence in their opinion solidifying their stance on the subject.

Rationale:

The topic of Marcellus Shale directly relates to the energy initiative that is the focus of many governments and groups around the world. The Marcellus Shale is a type of rock found throughout much of the Northeastern part of the United Sates.[1] It has come to be more recognized these days because this particular rock has a special quality that makes it very valuable in today's economy. It happens to have a gargantuan amount of natural gas locked inside of its structure. Consequently, this has lead many industries and companies to this part of the world to learn more about the potential of this rock to provide our country, and maybe the world, with energy. Our search for energy sources is not a new process for Pennsylvanians, or our country for that matter. After all, the first oil well drilling in this country took place in Titusville, PA in 1859.[2] It has long been understood that our need for energy takes a high priority in our lifestyle. So much so, that national and state policies regarding energy are designed to increase supply and demand of the resource. The general perspective that states have towards the energy industry is how energy policy is directly coupled with economic welfare and environmental protection. This mentality has lead to the exploitation of the environment and its resources for the sake of our state's "economic welfare." Furthermore, Pennsylvania, along with many other states, has identified energy policy to be directly correlated to states' economy in two ways[3]:

1) Energy costs represent a major controllable, operating cost for industry and commercial businesses. Price hikes and shortages are disruptive.
2) Economic development in the state is dependent on having an available supply of affordable energy.

This is especially true for alternative energy which provides a new market for state economic growth (ex. ethanol fuels create an attractive market for agricultural states).[4] With so much emphasis being placed on energy it is clear to understand all the attention that has been given to Marcellus Shale.

Indeed, it does seem as though we are situated over a "world class resource" located right in our own backyards. The objective of the project is to make students active stewards in this issue. Hopefully, this will spark their curiosity so that they become more aware of the opportunities that may exist in the energy industry as well as the impact it will have on their future. By doing so, they will be prepared for the challenges that our future world will certainly face.

The unit objectives will be achieved by engaging the students in a thorough process of research, activities, and labs designed to help them gain a robust understanding of the material. In other words, the process will allow for the students to achieve a mastery of the subject matter. The end of the project will result in the students creating some type of presentation reflecting a sound argument on Marcellus Shale exploration in PA. To build up to the culminating project, students will have to explore the natural resource in detail. This will be done starting with the structure of the earth and its processes and continue until the students have reached a complete understanding of the relationship that is shared between us (human kind) and Earth.

Background:

To ultimately understand what all the fuss is about, the students must first understand the working of the earth's processes. To begin, the students will identify the different types of rocks that exist in our world: **sedimentary, metamorphic,** and **igneous**. They will understand how these rocks are formed as well as how the formation of the rock leads to its utilization as a resource (fossil fuels). The majority of the focus will be given to sedimentary rock and the processes that form it because Marcellus Shale falls into this rock category. Students will identify the process that creates sedimentary rock by looking into the concepts of **weathering, erosion,** and **deposition**. They will first understand that sedimentary rock exists at the surface of the planet and how, because of that, we are able to utilize it for many things. Next, they will learn how weathering from various types of precipitation and atmospheric conditions can cause rock to weaken and breakdown. This breakdown of rock allows for erosion to occur which uses wind, water, or ice to transport rock from its original source to a new location. Students will wonder where the sediment will be taken and what happens to it after it is eroded. This is when the concept of deposition will be introduced. They will understand that when sediment is added to a landform or land mass, it is referred to as deposition. This progression of sediment build up occurs continuously and has been happening since the beginning days of this planet. While sediment builds on top of more sediment, organic materials can sometimes be trapped by deposition. This creates conditions that are necessary for the formation of fossil fuels. **Fossil fuels** are Earth's natural resources that provide us with much of our energy we use daily. The energy it supplies us is due to the processes that trapped the organic materials in the earth so long ago. Once the students can gain a good grasp of these ideas they will be able to progress to the next stage in the unit. Here they will spend more time focused on fossil fuels and the effect they are having on our environment.

When discussing fossil fuels, it is vital that students understand the processes behind the creation of theses resources of energy. This is why the natural earth formations and its processes are viewed first. Once those concepts are proficiently understood, they will focus on two fossil fuels in particular: Marcellus Shale and coal. Both resources have strong ties to Pennsylvania;

however coal can be looked at as a predecessor to Marcellus Shale since the Marcellus Shale formation has not yet been fully realized. Because of this coal is still a prominent energy resource for Pennsylvania. With this in mind, students will investigate into the history of coal in Pennsylvania and identify if there is anything to be learned from this previous case. This information can then be applied to our current situation with Marcellus Shale. To culminate their lessons on fossil fuels, the students will also explore alternative methods for energy and compare their viability to our own Marcellus Shale.

Pennsylvania's earliest record of coal mining is from the year 1761.[5] There is no doubt that since then Pennsylvania has reaped the benefits of exploiting this resource. Coal is directly responsible for the presence of iron, steel, chemical, glass and metal fabricating industries in Pennsylvania. This is because much of the railroad network that exists was constructed specifically for the transportation of coal. This also happens to be very necessary for the success of the aforementioned industries above. Therefore, the use of the railroad network was widespread, dispersing economic wealth throughout the state. While the economic wealth could definitely be looked at as beneficial to the state, the environmental toll that the extraction of coal was having on the environment was also evident. Acid drainage caused extensive pollution of streams and loss of fish and other wildlife. It also led to the disruption of groundwater resources, soil erosion, and scarring of the land.

The value of coal is undeniable. It provides energy for almost all of mankind's daily activities. The obvious use of coal can be seen everywhere around us in each facet of our lives. However, some of the more unknown uses for coal could end up being just as valuable. Scientist believe there could be some mystery benefits that hydrocarbons could offer our world if they can be sustained. To understand the true complexities of coal, students must understand how it is composed. Understanding this will give them insight into the value of other resources. The first thing the students will understand about coal, and other fossil fuels, is that they are composed of thermally altered and highly compressed plant material that grew millions of years ago in swamps and then was buried under a great thickness of sand and mud. When the plant material is buried, it is buried with the energy that it collected from the sun during its lifetime. Most coal is made up of the basic elements carbon, hydrogen, and oxygen. When these elements combine, they take up energy and contrarily release energy when broken down to their original state.[6]

For the process of turning plant material into useable energy, a few requirements must be met. The first requirement is that trees and other plants must be in abundance in and around swamps. In the Pennsylvania region, this is especially evident by the numerous parks and forest that make up most of the state. The next requirement is that the twigs, branches, and leaves must settle to the bottom of the swamp and lay the foundation for more debris. This has to be matched with stagnant swamp water, which allows **peat (accumulation of partially decomposed plant material)** to form. Finally, different reactions must take place in order to lock in the energy stored in its compounds. One reaction is biological and chemical, utilizing bacteria to trap the energy; another type of reaction is physical and chemical which utilizes heat to mold the energy into the form we exploit today.[7]

When it comes to Pennsylvania, all of the coal we extract was deposited during a portion of Earth's history named in honor our state, the Pennsylvania Period. The aforementioned

process **(referred to as coalification)** occurred continuously until a sequence of rocks more than 4, 000ft thick was formed. With such an abundance of coal, our society and state has overused the resource. The overuse has lead to many negative effects on the environment, including the most notorious Greenhouse Effect. At this point in time this topic seems to take priority over others. However, because of our pressing need for energy, we have been forced to explore other avenues that might help quell our thirst for energy. The students will briefly identify these alternative types of energy resources. They will draw conclusions about which are the most practical uses of energies and how we should go about utilizing them. Some of these alternate types of energy include: solar energy, wind energy, tidal energy, geothermal energy, etc. Understanding the complexities of the energy industry will give the students perspective when analyzing the public's desire to extract Marcellus Shale.

To make their arguments stronger, the students will also need to explore the characteristics of the Marcellus Shale. To begin with, the Marcellus Shale Formation is found in the Devonian section of the geologic time scale. It has formed in very much the same way coal has formed, thus giving it many of the same qualities as coal. This particular sequence is more than 10,000 feet thick in eastern Pennsylvania but thins to about 2,000 feet along the Lake Erie shoreline. The Marcellus Formation underlies most of Pennsylvania, but the organic-rich portion reaches its maximum development in the northeastern part of the state. Despite the long history PA has with exploring natural gases, it took until recently for its potential as a commercial gas target to attract attention. Without the proper technology, it was nearly impossible for any company to profit from Marcellus Shale extraction. Now that the technology exists, energy companies are able to engineer the drills to take advantage of the Marcellus Formation's structure. A system of fractures in these shales constitutes the most important part of the reservoir by providing porosity and permeability that allows the gas to leak slowly from the rock.

All the fuss made over the Marcellus Shale would bring you to believe this was some newfound world-class resource waiting to sustain America's need for energy for decades. In actuality, the Marcellus Shale in PA has been a known gas reservoir for more than 75 years. What has made it newsworthy, besides much hyperbole, is that the oil and gas industry has both new technology and price incentives that make this otherwise difficult gas play economical.[7] In the 1930s, the oil companies stumbled onto the discovery of the Marcellus Shale while searching for more oil reservoirs. The strong back flow of gas caused the companies to temporarily shut down. However, this newly discovered resource immediately caught the fascination of the company. That is, until they recognized that the gas only existed in pockets. Without the proper technology, the company couldn't efficiently extract the gas. Accordingly, the breakthrough of the new technology, Hydraulic Fracturing, has catalyzed the increasing interest in the Marcellus Shale.

Marcellus Shale interest faded away for some time after its discovery in the 1930's. Then came the energy crisis in 1973, when all stances on energy had to be reevaluated for the sake of the country. During this period of time, an abundance of new Marcellus Shale resources were found along with new technologies that would help with increasing the production of energy. During the 1980s, the demand for gas became stagnant as gas prices lowered and technology was still inefficient. Contrarily, the reverse has now taken place. This has caused demand for the

Marcellus Shale gas to skyrocket with companies paying incredible fees for leases while others spend fortunes to drill Marcellus gas wells across the state.[8]

As previously mentioned, one of the main catalysts for the surge in Marcellus exploration stemmed from advances made in the technologies used to extract gas from the Marcellus Formation. The most popular technique used today is referred to as Hydraulic Fracturing, which is done using horizontal drilling. Both of these technologies have been around for years however only recently the advances made the natural gas industry boom in the state of PA. Both technologies stem from the discovery of pores, or perforations in the Marcellus Formation that existed in pockets throughout the formation. These pockets of gas provide an opportunity for the natural gas to leak into them and then be extracted for use. However these natural pockets are not consistent throughout the formation and often don't provide enough natural gas to make the process profitable. Therefore, the energy companies had to move to more conventional reservoirs where the gas was more easily extractable.

The natural fractures in the Marcellus Formation were neither numerous or as extensive as mentioned above; this lead to advances in **Hydraulic Fracturing, or Fracking**. Fracking can be done in different ways using a variety of substances to enhance the effectiveness of the process. In general, hydraulic fracturing involves pumping a fluid such as water or kerosene and sand or some other granular material into the producing formation under high pressure until the rock cracks. The process enhances the porosity and permeability of the rock, and the granular material (the proppant) serves to prop open the newly created fractures. As a result, the surface area of the rock increases, allowing gas to travel more readily from the pores to the well bore.

Another technique that has become useful in collecting Marcellus gas is horizontal drilling. This technique, combined with hydraulic fracturing, has made drilling for natural gas more accessible than ever. It is possible that if either of these technological advances had not existed, the Marcellus Shale would also be a non- issue. Again, we see that newer technologies are sometimes just adjustments to older technologies as is the case with horizontal drilling. The first horizontal well was drilled in Texas in 1929, but it took until the 1980s for the technology to be improved enough to become a standard industry practice. The technology involves drilling a vertical hole to several hundred feet above the target reservoir, then directing the drill bit through an arc until it is literally drilling sideways instead of downward. This has several advantages as listed below[9]:

1) It increases the amount of reservoir penetrated from perhaps a few tens of feet to as much as 3,000 or 4,000 feet;
2) It increases the number of fractures penetrated; and
3) It can be used to develop hydrocarbon resources beneath sensitive areas such as wetlands and cities where a drilling rig cannot be set up.

Unfortunately, there is a down side to the new technology that has shaken up the natural gas industry. The biggest fear of many opponents of the Marcellus Shale is that the technology used for extraction will lead to severe contamination of the nearby groundwater. This is a major issue for people because they realize the implications of the contaminated groundwater. Groundwater is water that is present in the interconnected void spaces between geologic

materials within the subsurface. Because hydraulic fracturing penetrates to these levels, it is clear that the process poses a serious threat to the nearby groundwater. This is also disturbing because this particular groundwater happens to be directly upstream, along the Delaware River, from major cities and urban developments. Therefore, the potential damage could be devastating to the people and environment that localize around the Delaware River watershed. This congregation around major waterways is nothing new. In fact, it is said that over half of humanity lives in cities during this day in age. The world is becoming increasingly urbanized. When looking at the history of urbanization, it is evident that the process can have negative affects on society as a whole. This is particularly true when it comes to the industrialization of America and more specifically Pennsylvania.

One would think that Pennsylvania's first hand experience with fossil fuel extraction would serve as a deterrent if a similar scenario were to present itself. However, this is not the case. In reality, Pennsylvania still has some of the most lenient regulations on the removal of natural resources in the country. The contradiction is startling, but nonetheless Pennsylvania finds itself in this current state of mind. The mistakes of the past are glaringly evident, however they pale in comparison to the potential effect that hydraulic fracturing could have on the region. It is known that pollutant load frequently leads to poor water quality; indeed this adverse impact of urbanization often extends to the water course downstream of the urban area (representing a clear threat to public health).[10] To understand the importance of water quality, it is essential to understand that it is a function of its chemical, temperature, and other physical properties. When ground water is exposed to these contaminates it can severely disturb the properties previously mentioned. This has ominous implications since ground water is often used to meet human and natural demands, maintain aquatic ecosystems and can constitute a significant proportion of a stream's total flow. Being downstream from an event like the Marcellus drilling can have calamitous effects for plants and humans, two major parts of any ecosystem. For humans, certain contaminants have been found to be carcinogenic, disruptive to endocrine activity, toxic at high doses and the source of a myriad of other negative health affects. For plants, high levels of salinity can have deleterious impacts. These affects are quite problematic, and thus need to be attended to expediently.[11] The sooner the better because once the contaminants are in the groundwater, concentrated plumes of contamination can migrate kilometers and ultimately discharge to surface waters and/or extraction well. This implies that little contamination is needed to seriously harm our ecosystem and surrounding environment.

Finally, to conclude the unit, students will be responsible for enlightening the public about the advantages and disadvantages of drilling for the Marcellus Shale. The student's audience will be their peers as well as local state representatives; this will facilitate making the students active stewards in their community. Included in their statement will be a proposed solution to the Marcellus Shale dilemma. Because we are years into the process of extracting Marcellus Shale, the focus of the essay will be on finding common ground for social, political, and economic interests of everyone involved. The arguments presented by the students intend to mediate the back and forth dialogue that is currently taking place and getting us nowhere. By presenting their arguments, the students will have done their part in attempting to improve the quality of living of the residents of this region.

Before the students can write their solution statement they must first discover the wealth of information that can be found on the Internet regarding this topic. One of the major issues plaguing much of the public today is knowing what information is trustworthy and what information should be disregarded. With the amount of usage the Internet gets in today's society, any bit of information desired is at the tips of their fingers. As teachers, we want to make sure that our students are adequately informed. To do this they must know the difference between a reliable and unreliable source on the Internet. Therefore, the teacher should demonstrate the proper way to conduct research on the Internet. After this is completed, the students will be prepared to complete their essays and present them to whomever they desire.

Objectives:

The material for this unit will be presented with a focus on geology and its applications to the Marcellus Shale Formation. The Marcellus Shale covers many different concepts and topics that could be discussed at length. However, to stay true to the 6th grade science curriculum given by the Philadelphia School District, the unit has been designed to align with their core standards. A major emphasis will be put on the students gaining a deeper understanding of the standards by exploring the impact of the Marcellus Shale in Pennsylvania. The targeted audience for the unit spends the first part of their year, as 6th graders, learning Earth Science and the various dynamics of the processes that created the Earth. Unfortunately, the students become discouraged with the lessons and claim the material to be boring and uninteresting. One reason for this disconnect could be the irrelevance of the material to anything they experience in their daily lives. In my experience, most students who are unable to relate to the material often quit and block the memory from retaining the unrelated information. This becomes frustrating for both the student and teacher. Accordingly, the unit proposed intends to eradicate the frustration and discouraging nature of the current curriculum by introducing material relevant to their lives. The Marcellus shale is current and more relevant than almost anything else they will learn during their 6th grade year in Science. In addition, applying it to Geology and the core standards will improve how they understand the concepts during the 1st part of the year. This will occur by improving on their thinking processes as well as how they perceive the Earth and is natural processes. By enhancing their understanding of processing skills, students will increase their chances of becoming active stewards in this tumultuous world of change, which is ultimately the overarching theme and objective for this unit.

Fully understanding the geology of the Marcellus Shale Formation requires the students to investigate many facets of the topic and its relation to themselves. The following four topics attempt to thoroughly analyze the complexities of the issue, demonstrating to students the pertinence of recognizing how the issue applies to them. The first topic discussed will elaborate on the formation of the Marcellus Shale through the process of the rock cycle and other earthly mechanisms. The second topic will extend the discussion of the rock cycle and focus on the formation of fossil fuels and their role in our society. Thirdly, the unit will investigate the technology being used to extract the Marcellus Shale from the Earth and include a discussion on the connection between technology and the health of the Earth. Lastly, the students will conclude the unit by bringing it all together to understand the impact of humans on the environment. The students will utilize all that they have learned during the unit and provide a presentation to the class regarding the human impact on the environment.

Each topic to be covered has its own objectives. The goal is that when each topic is completed the students will fully understand the concepts and prepare them to formulate their own arguments by the unit's end. Accordingly, the first topic regarding the rock cycle and the formation of the Marcellus Shale will be geared towards providing the students with solid background information giving them a strong foundation for future lessons in the unit. The background information will emphasize the stage of the rock cycle that created the Marcellus Shale. Students will then be able to connect what they know about rock formations to the Marcellus Shale and draw conclusions about its qualities and practicality. Therefore, the objective for this section of the unit is to ensure that the students understand enough background information to progress confidently throughout the rest of the unit.

The second topic consists of identifying what a fossil fuel is and how it is created. The formation of fossil fuels is closely related to the formation of all rocks, particularly sedimentary rocks. Thus, the students should have little trouble identifying the connection between fossil fuels and the Marcellus Shale. Once this connection is solidified, the students will have obtained the objective of understanding how fossil fuels are able to generate so much energy and why our dependency on them has left us in desperate need of some sort of alternative. Recognizing these concepts will help them become active stewards in the community and world, which ultimately is an objective that all teachers hope to achieve.

The third topic will focus on the technology being used to extract the Marcellus Shale and the overall impact that humans have on the environment. The implications of this stage of the unit couldn't be more relevant and specific to the generation of students we have today. Consequently, it is essential that students take away from this section a complete, robust understanding of the concepts detailed. If nothing else, the students must understand how pertinent this issue is for our world and draw conclusions about possible solutions to alleviate the immense stress our world experiences because of human activity. This accentuates the overarching theme of both the section and unit. If the students can walk away with an understanding of these concepts then there is a chance that they could one day play a vital role in changing our current course and improving our way of life.

Strategies:

The unit steps away from traditional styles of teaching and emphasizes student learning through their own experiences. This unit attempts to let the students dictate the process and pace of learning. By no means is this a case of prisoners running the asylum, but a scenario in which the students learn from their experiences more than anything else. The teacher will thus serve as a facilitator, lending support and guidance whenever a student faces challenges. Students will then dictate to the teacher what interest them the most and explore those interests in more detail. To assist the students with their newfound responsibilities, the teacher will provide a multitude of resources and guidelines to prevent the students from falling off task. By implementing this strategy students will create a sense of ownership regarding their work, which will improve their motivation and desire to succeed. As a result, students' confidence will increase catalyzing a dramatic effect on their overall academic success. This will be due to the confidence they gain in their processing skills and ability to complete given tasks. These strategies provide the students

with a taste of success, which some of them have never experienced in a classroom setting. Consequently, experiencing success will lead them to desire that feeling again, motivating them to aspire for greatness in and out of the classroom.

The particular strategies that will bring about these types of achievement include collaborative learning, project based learning, experience driven learning, and finally an interdisciplinary approach to broaden students' horizons. Each strategy is necessary for the students to optimize their understanding and performance in the unit. These strategies aim to encourage students to identify how the topics of the unit can be correlated. By building the connections between the topics, the students will gain a more robust understanding of the material.

The first strategy, collaborative learning, will be implemented throughout the entire unit. Each assignment will require a group to complete. To avoid repetition and loss of interest students will be also be required to switch roles for each assignment providing them with a variety of responsibilities to enrich their learning experience. The students will also benefit from utilizing each others' strengths and weaknesses to improve their comprehension of the material. To ensure diversity is present, the teacher will designate students to a particular group. This will create a stimulating atmosphere for the students, one which will include students of high and low levels cooperating to accomplish a common goal. This will intuitively produce a differentiated climate in which students can thrive, since they will generally accept roles they are comfortable with. The initial comfort the students will experience adjoined with small successes should provide them with the confidence to take on more challenging roles.

The second strategy to be implemented will reinforce process skills necessary to complete any project or group activity. The process skills needed to complete projects are essential for many careers and daily activities in life. Accordingly, engagement in project-based learning will establish the process skills needed to achieve success in all areas previously mentioned. By the end of the unit, students will have a firm understanding of the process used to complete a project. The process is comprised of different stages, which ensure the student's success. The stages will be matched with deadlines for particular assignments. The deadlines are intended to walk the students through the entire process, emphasizing crucial strategies and skills when necessary. For example, the proper techniques to complete proper research will be heavily emphasized. Developing strong research skills will help the students in a multitude of fields. In addition, enhancing their research skills will give them the ability to generate their own arguments and articulate them in a way that is clear and succinct.

Students can often become bored if they are fed the same information the same way for an extended period of time. The key to their boredom stems from the traditional methods used to teach them the material. In contrast, by incorporating interdisciplinary lessons in conjunction with experience driven learning, the students are kept off guard, not knowing what to expect. This sense of mystery eliminates boredom, and sustains a student's motivation and excitement for the material. Thus, this unit will implement both of these strategies to keep up the student's interest in the lessons. The experience the students will gain from the hands on lessons will stimulate and sustain their excitement by consistently engaging the students in activities that keep them busy and on task. Encompassing all of the aforementioned strategies gives the teacher

and the students the flexibility to be successful in a variety of ways. Therefore, it's critical that they are implemented for this unit so that all participants are able to achieve some type of success.

Classroom Activities:

Lesson One: "Got Rocks on Rocks on Rocks"

Objective: *Students will be introduced to the various qualities of rocks and the processes that produce such qualities. Students will use information to understand the relationship that is shared between the qualities of rock and the processes that make them up.*

Warm Up:
Students will begin the lesson responding to the introductory statement: Identify three characteristics of a rock. Then, briefly explain how humans can benefit from any given characteristics of rocks.

Directed Instruction:
Following the introductory question, students will engage in a follow up assignment. The assignment will consist of them reading aloud a short passage and answering questions. Then, the teacher will explain to the students how the characteristics they mentioned earlier were created along with the invaluable resources that various rocks provide us. This will be accompanied by PowerPoint point slides and videos to help reinforce the concepts. It is essential for the students to understand the process that rocks undergo in creating the magnificent resources that are exploited by humans. Robustly comprehending the process will enhance the students' chances of making a connection between Marcellus Shale and the energy it provides us.

Guided Practice:
Following this, the teacher will demonstrate how to access the wealth of knowledge that can found on the Internet. Students observe how to navigate the Internet and isolate information relative to your topic. They will also understand how to distinguish a reliable source from an unreliable source, strengthening the quality of information they acquire.

Independent Practice:
Students will begin their own research by utilizing the strategies they witnessed, exploring all facets of the Rock Cycle and the Marcellus Shale Formations. Their research will be guided by procedures given to them by the teacher. The procedures will help them to identify information pertinent to their topics by guiding them to specific websites with respectable reputations. After collecting their information they will paraphrase it in the form of a couple of paragraphs. The paragraphs will detail how the new found information has changed their perspective on rocks and their value to humanity.

Closing:
To conclude the lesson, the students will share what they have written with the class. The class will then discuss their new perspectives and provide feedback to one another about how they look at rocks differently.

Homework:
Use the information you learned today in class and write a one page essay explaining the impact that they believe the extraction of the Marcellus Shale Formation will have on the ecosystem and people of the region.

Lesson Two: "Live Streaming Table"

Objective: *Students will understand the impact nature has on the natural environment. They will also simulate a few of the earth's processes to gain a deeper understanding of the connection the processes have with Earth.*

To supplement the concepts learned during the previous day the students will participate in an activity that helps them understand the formation of rocks and minerals. The activity is titled Modeling Stream Erosion and Deposition and uses a stream table to demonstrate the impact flowing water can have on local environments. This will lead to an understanding of how Marcellus Shale is formed and the impact that extracting it could have on the environment and ecosystem. The instructions and procedures for this experiment can found in the appendix with an example of what a stream table could look like if set up properly.

Homework: Complete Lab Write Up of completed experiment

Lesson Three: Fossil Fuels: Human's Dirty Secret

Objective: *The students will identify different fossil fuels and elaborate on the impact they have to our planet. They will then be able to distinguish between renewable vs. non-renewable, along with clean vs. dirty energy.*

Warm Up:
Students will begin by responding to the following introductory question on fossil fuels: Imagine a way in which rocks and other earth resources could be used for energy and attempt to explain the process.

Directed Instruction:
This week will be spent focusing the students' attention on Marcellus Shale and the benefits and costs of participating in this endeavor. They will begin to fully understand the process that will be necessary for the change of shale to liquid gas that can be used for automobiles, heating homes, and other situations where liquid gas can be used. This will be achieved by having the students perform more research on the topic.

Guided Practice:
Some of that research may include reports given by the EPA and companies that are invested in the project. It may also include listening to testimonials given by people who will be most affected by initiating this project. The teacher will provide all materials needed for this research.

Independent Practice:
Students will perform research and identify key facts to support their sentiments towards their topic. After they have found an adequate amount of research they will write a one-page essay paraphrasing their research. Additionally, they will explain how their research supports their argument in regards to extracting Marcellus Shale.

Closing:
Students will share out with the class specific selections from their research and explain how it has enhanced their argument.

Homework:
Complete essay at home if you were unable to complete the assignment in class. In addition, complete Research Follow Up worksheet to be handed in the following day

Lesson Four: Solar Greenhouse Effect

Objective: *Students will construct a model of a solar green house and identify the several different factors that create a balanced temperature on the planet.*

In this lesson the students will participate in an activity that reinforces the importance of maintaining proper balance on the Earth. They will construct solar greenhouses that will simulate the behaviors of the Earth. This project will take several days. The students themselves should provide much of the materials needed for this activity, unless there are sufficient resources available on site. The procedure for constructing the solar greenhouses can be found in the appendix. When the solar greenhouse is complete the students will place the greenhouse in a location that receives direct sunlight and observe the results.

Lesson Five: A Fracking Mess

Objective: *Students will begin to understand the impact humans have made on this planet. They will also identify the ways humans can prevent and solve our current enery crisis.*

Warm up:
The students will be asked the following question to spark their curiosity and begin the lesson: Scientist now label this time in history as "The Anthropocene," referring to the significant impact humans have had on the planet's health and ecosystems. Please explain how scientist can make this claim and provide evidence to support.

Directed Instruction:
Students will gain robust understanding of human impact on our world by looking into Pennsylvanian's past and learning about former experiences with fossils fuel extraction. They will use video and articles to paint a picture of how the extraction of coal from Pennsylvania mountains has impacted out region.

Guided Practice:
This will be followed with a teacher led discussion on how Pennsylvania's experience with coal extraction plays a crucial role in the state's history. The discussion will include a story of ambition adjoining with greed, what is best for the environment and people, and can the two (environment and people) be separate but equal. These complexities tell part of the story of Pennsylvania. The students will understand that and be asked to write the story of the Marcellus Shale and the impact it will have on this region.

Independent Practice:
Students will begin work on their stories. The story will not be completed in one class period and thus this lesson will last several days, giving time for rough draft and editing strategies.

Closing: Students will brainstorm aloud with the class and share some of their ideas about their Marcellus Shale story.

Homework:
Continue to work on your story at home. Have rough draft ready for class the next day.

Lesson Six: Quality of Water = Quality of Living

Objective: *Students will identify the role water quality plays in human lives. They will then understand how impactful it can be for humans if their water becomes contaminated.*

This week students will use the information they have collected over the past several weeks and apply it to designing and performing experiments that test water quality, air pollution, and the long-term effects of drilling for gas in Marcellus Shale in the state of PA. After they design their experiments with the assistance of their teacher, the students will attempt to complete their experiments and determine whether or not there is reason to believe the extraction of Marcellus

Shale gas will have a positive or negative effect on Pennsylvanians. By the end of the week they must have made a conclusion or decision on what the State should decide to do with regards to Marcellus Shale exploration. The procedure and additional instructions for the experiment can found in the appendix. Due to the use of toxic chemicals the teacher will provide all materials.

Appendix

Lesson Two: Live Streaming Table Activity

Materials: Stream table; sand; watering can; bucket or cup for pouring water; water; extra sketch paper

Keywords: stream; channel; braided stream; meander; landform; erosion; deposition

Purpose: to observe the ability of a stream to erode, transport, and deposit materials.

Procedure

1. Prop up one end of the stream table to about 3 to 5 cm. Fill the raised end of the stream table with fine sand. Pick up the raised end and shake the stream table gently until the sand covers about the top two-thirds.

2. Begin pouring water, slowly and steadily from a watering can that is held slightly above the high end of the stream table.

3. Observe the small stream that is forming in the sand.

4. What happened to some of the sand as the water flowed over it?

5. Where did the sand go?

6. On a separate paper, make a detailed sketch of the landforms in the stream table.

7. Would you characterize this as a meandering stream or a braided stream? Explain your answer.

8. Smooth the sand and use your finger to create a winding, meandering channel. Pour a steady

trickle of water down this channel.

9. Are you able to see where erosion is occurring in the meandering stream? Where?

10. Are you able to see where deposition is occurring? Where?

11. Make a sketch of the meandering stream and label areas of erosion and deposition.

12. Now find out what happens in a flood by pouring more water faster down the channel. Describe what happens to the channel and to the sand.

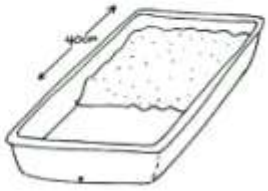
13. Make a sketch of the stream under flood conditions.

14. Do you think the stream would look the same if the slope were steeper? Prop up the stream table to make the slope greater than before and pour water, slowly and steadily, from the watering can. Describe any differences you see in channel development or particle movement from the previous channels created at a shallower slope.

15. What would the landforms in the stream table look like if two or three watering cans made streams at the same time?

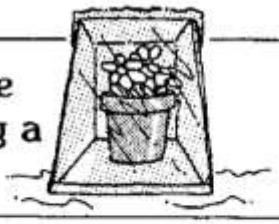
16. Find out by pouring water at the same time from two or three different watering cans. Do stream channels merge? Are some channels abandoned? Are flood conditions reached quickly or not at all? Are the deposits at the mouths of the streams large or small? Describe what you see and make a detailed sketch.

STREAM TABLE IDEAS

What happehs if you dam the stream? 	What happens if you build levees along the river channel? 
What happens to houses on the edge of the stream channel during a flash flood? 	What happens if you build a mountain in the middle of the stream table? 
What happens if you use two water sources, instead of only one? 	What happens if you use many water sources, like an egg carton with holes? 
What happens if you allow sea level to rise by plugging the outlet hole? 	What happens if you spread the earth material out 40 cm instead of 20 cm? 

Lesson Four: Solar Greenhouse Activity

How much better is a solar greenhouse than a standard greenhouse at keeping a steady temperature in the winter?



Materials

Corrugated cardboard (figure amount needed based on drawings)

Clear plastic, 3- or 4-mil, 50cm x 450cm (local hardware or garden stores)

Flat black spray paint

White spray paint

2 Thermometers

Plastic wrap (grocery store)

Tape

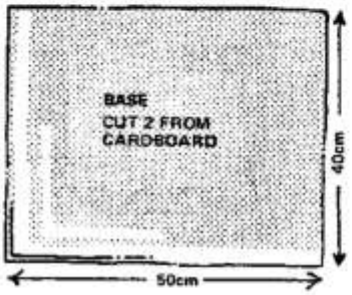
String or thread

Tin cans

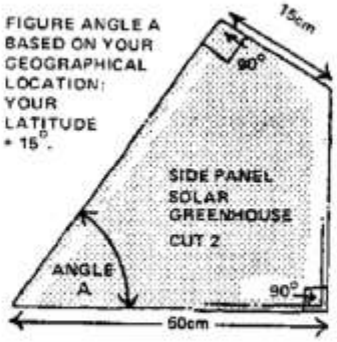
Rubber bands

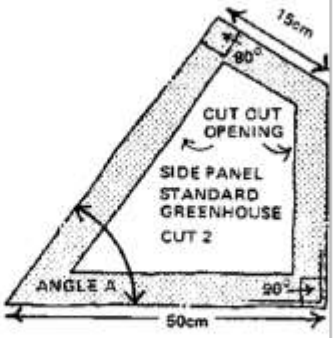
Insulation material (styrofoam, cardboard, newspaper, etc.)

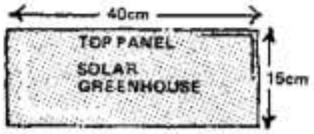
Build a Solar Greenhouse

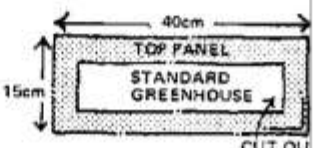


Build a solar greenhouse and a standard greenhouse according to these drawings. (Be sure to cut 2 of each side panel.)

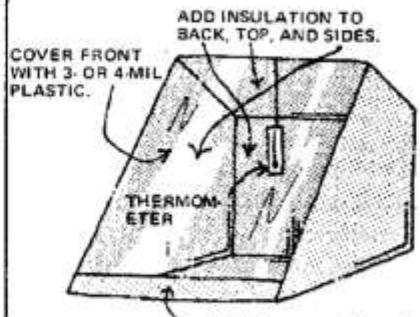


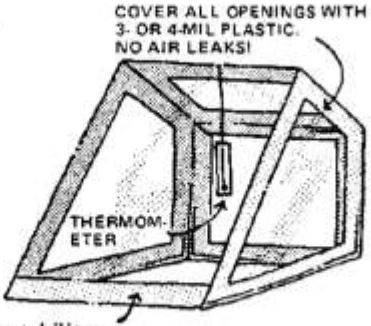






Spray the outside of the greenhouses white before adding plastic.





Add 5cm cardboard panel for stability.

Conduct Your Experiment Like This:

Face both greenhouses directly into the sun.

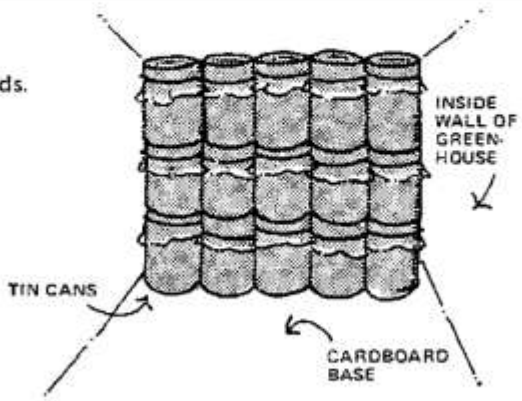
Measure and record the temperatures in each one as the day progresses.

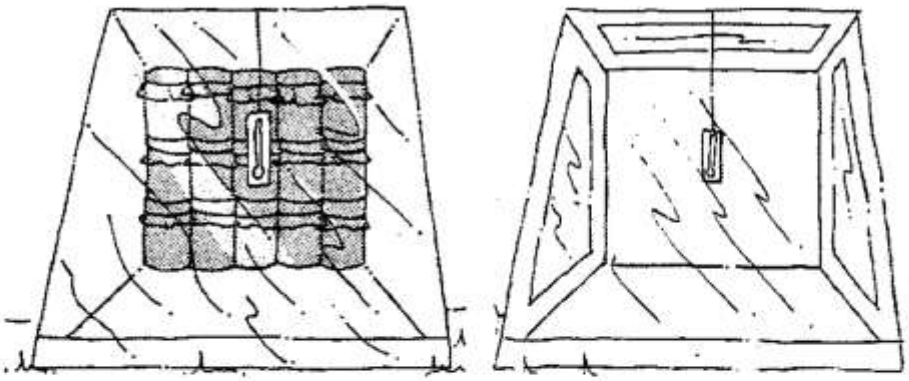
After they have reached a high temperature place both in the shade—read and record the temperatures as they cool off.

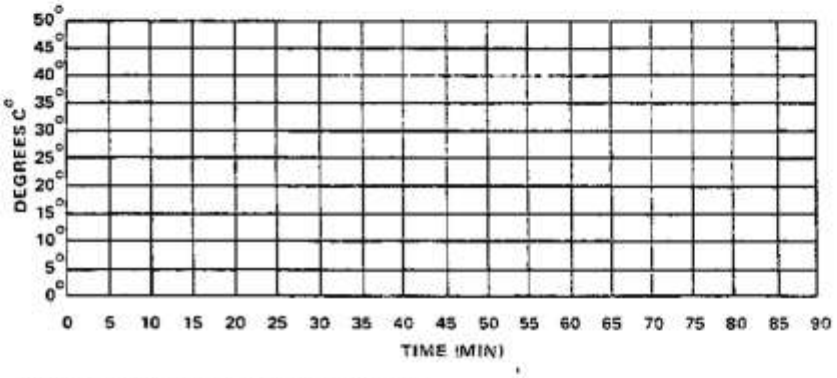
Spray the cans flat black.

Fill with H_2O and cover tightly with plastic wrap and rubber bands.

Stack them in the back of the solar greenhouse.







Graph the results of your experiment.

Other Ideas to Explore

What would happen if you added more insulation material? What if you added 2 layers of plastic to the front?

What are other ways of maintaining and storing heat when there is no sunlight?

Try substituting gravel, sand, and soil for H_2O in the tin cans in the solar greenhouse and try the experiment again.

Would you save energy in your climate by using a solar greenhouse?

Lesson Six Activity

Chemically Testing for Water Quality

PURPOSE:

- To test surface water for water quality. Tests will be for pH, Dissolved Oxygen, Bacteria (coliform), Carbon Dioxide, Alkalinity, Hardness, Nitrates and Phosphates

- To analyze the data obtained to assess the overall quality of the body of water.

MATERIALS:

1. Hach or LaMotte water test kits which contains tests for pH, DO, CO2, alkalinity, hardness
2. Individual Hach test kits for nitrates & phosphates
3. Presence/absence kit for Total Coliform
4. Thermometer

PROCEDURE:

1. Obtain a pail of water from the body of water that you are investigating.
2. Record the following information about the sample:

Date: Location:

General description of the source of your water:

pH

pH measurements are taken from water because this is an indication of whether the body of water might be contaminated-especially if the pH is above or below the normal range.

Follow the instructions in the test kit to determine the pH of your water sample.

1. What effect would this pH have on living organisms in the water?

2. What effect would this pH have on plants in the water?

3. What are some factors that could cause this particular body of water to have its pH?

4. What is an acceptable pH range foremost aquatic life?

Coliform bacteria

Another excellent indicator of water quality is based on the number of coliform bacteria. Coliform bacteria normally live in the intestines of mammals and are excreted with the fecal wastes. Some forms are pathogenic, but even if they are not their presence in water samples indicates that the sample has been through an animal intestine. The EPA does not allow any coliform bacteria in drinking water. The test that you are performing only determines the presence or absence of the bacteria. It gives no indication of the number of bacteria present. To obtain this, you would need to do a colony count.

Procedure:

1. Open the vial, being careful not to contaminate the broth. Pour the water sample into the vial and close the cap.

2. Incubate for 24 hours at room temperature.

3. I f the color changes from reddish purple to yellow, this indicates that there are coliform bacteria present.

4 Dispose of your bottle as instructed.

The coliform bacteria test was _____(positive,negative)

Interpretations:

Using your knowledge of the site from which the water sample was taken and the test results, write a simple analysis to account for your results. If the test is positive, where do you think the coliform bacteria came from?

Alkalinity

Alkalinity is a measure of all of the substances in water which have the ability to react with the acids in water and "buffer" the pH; that is the power to keep the pH from changing. Pure water would have a pH of 7 and therefore has no (zero) alkalinity. Alkalinity is important for aquatic life because it protects or "buffers" as much as a Tums or Alka Seltzer does in your stomach. It keeps the pH from changing and makes the water less affected by factors such as acid rain or acid spills. The main sources of alkalinity in water are rocks which contain carbonates or bicarbonates and respiration. Limestone is a good example of this type of rock. Water with a total alkalinity of 100 - 120 ppm is considered to be the best water for fish and aquatic organisms. Lakes with a total alkalinity of below 50 ppm are considered "too clean" and will support little life, while lakes of 200 ppm are quite high. Alkalinity can be increased in water by adding lime to it. Alkalinity is considered a fairly reliable measure of the productivity of a body of water.

Procedure: Follow the instructions in the test kit.

The alkalinity of the water is _____ ppm

Alkalinity is measured in of $CaCO_3$.

Interpretations:

1 Is this body considered to have high productivity or not?

2. Why would alkalinity of rainwater increase as it runs though the soil?

3. Considering the location of the site from which this water sample was taken, what might the source of the alkalinity?

Carbon dioxide

Green plants carry on photosynthesis only in the presence of sunlight. They, as well as the animals in the water, carry on respiration at night. Therefore, more carbon dioxide tends to build up in water during the night than in the daytime. If carbon dioxide levels are high and dissolved oxygen levels are low, fish have trouble carrying on respiration and their problems are worse if the water temperature rises. Fortunately for fish, "free" (uncombined) carbon dioxide rarely exceeds 20 ppm and most fish can survive in this amount with no ill effects; higher levels than this for any length of time can be lethal.

Procedure

Use the kit and test for carbon dioxide.

Carbon dioxide level of this water was _____ppm

Interpretations

Using your knowledge about the origin of this water sample, write a sentence or two summarizing your findings.

Hardness

Hardness in water is the amount of calcium and magnesium in the water. The natural source of hardness is usually limestone rock. The most frequent test performed on water is for total hardness. Hardness is important to living organisms because soft water makes heavy metals such as mercury and lead more poisonous to fish. Some nonmetals such as ammonia and certain acids are also more toxic to fish in soft water. There is some evidence that humans who drink soft water over a long period of time are more susceptible to cardiovascular disease. Vertebrates need

calcium to build bones. All living things need calcium and magnesium in order for proper cell functions. Chlorophyll contains magnesium. Drinking water with a total hardness of 250 ppm is best. Over 500 ppm can make you very ill.

Procedure

Using the test kit, determine the hardness of your water sample.

Hardness of the sample was _____ ppm.

Notes

1) DCNR.STATE.PA.US, March 2009.
2) Power for the People: Protecting States' Energy Policy Interest In An Era of Deregulation: Mary M. Timney; (M.E. Sharpe, Inc, 2004), 11.
3) Timney, Power for the People, 46.
4) DCNR
5) DCNR
6) DCNR
7) DCNR
8) Oilshalegas.com, 2008. 1 Mar. 2010. <http://oilshalegas.com/marcellusshale.html>.
9) Oilshalegas.com
10) Water: Science , Policy and management: Richard Lawford, Denise Fort, Holly Hartman, and Susanna Eden; (American Geophysical Union, Washington, D.C. 2003), 147
11) Lawford and Fort, Water, 155.

Bibliography

Environmental Hydrology: Andy D. Ward, William J. Elliot; CRC Press, 1995

This book focuses on the relationship that water shares with the environment. Pertaining to this unit, the book offers information about the processes behind the movement of water throughout an environment. It also suggests possible impacts of what contaminated water could do to an ecosystem.

DCNR.STATE.PA

This website offers information regarding the geology of Pennsylvania. Along with the exploitation if its resources, the site provide extensive explanations about the processes that formed the land in Pennsylvania. The website can be used as form of reference to give background information in addition to specific information about Pennsylvania geology.

Power for the People: Protecting States' Energy Policy Interest In An Era of Deregulation: Mary M. Timney; M.E. Sharpe, Inc, 2004

In this book, the author explains the origin of the energy industry in America and how it has evolved over time. Particularly, the book discusses how we have come to reach the energy crisis we're in today. The sections of the book used for the unit focuses on the energy policy and its affect on society.

Penn State Study: Marcellus Shale Development Expected to Create 98,000 Pennsylvania Jobs by 2010, $14.17 Billion Impact, *PR Newswire* 27 July 2009. Wire Feed.

The article on Marcellus Shale in Pennsylvania highlights the most recent developments on Marcellus Shale and its impact on Pennsylvania. It specifically refers to increase in revenue Pennsylvanians will experience if they participate in the endeavor of drilling for Marcellus Shale

Oilshalegas.com 2008. 1 Mar. 2010. <http://oilshalegas.com/marcellusshale.html>.

This journal article discusses more information about Marcellus Shale in Pennsylvania. It explicitly identifies the processes that created Marcellus Shale and how natural gas can be retrieved from it.

New Approaches on Energy and the Environment: Policy Advice For The President: Richard D. Morgenstern and Paul B. Pourtney; Resources For The Future, 2004.

Our current energy crisis and its affect on the environment are highlighted in this book. The author attempts to solve the energy crisis by explaining to the President the best practices to preserve and sustain clean energy.

Water: Science , Policy and management: Richard Lawford, Denise Fort, Holly Hartman, and Susanna Eden; American Geophysical Union, Washington, D.C. 2003

The relationship that energy shares with our society is detailed in this book. It explains the relationship by breaking down the impact energy has on each aspect of our society and how it can be controlled.