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Environmental Engineering for Elementary Learners

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Introduction

When I was first tasked with creating a curriculum about environmental engineering for first graders I felt extremely daunted by the task that loomed in front of me. How was I going to interest my class of six-year old students in a curriculum that had nothing to do with unicorns, video games, or the latest dance craze? However, the more I thought about it, the less daunting it seemed. My students are natural problem solvers, always on the lookout for how to solve problems both in and out of our classroom.

Engineering is problem solving-based and uses scientific and mathematical concepts. However, I also needed to keep in mind that engineering is different from science. In engineering you must apply scientific and mathematical concepts to solve the problem. And the solution to the problem must be a sustainable and economically efficient one. These facts about engineering simply meant that my students would need to use evidence to support their reasoning while problem solving, instead of just throwing around random ideas which had no reasoning to support why they would work.

The idea of students using evidence to support their claims excited me. I work at Ross/Woodward, a classical studies inter district magnet school. Part of our curriculum includes the Paideia style seminars so that students can explain their thinking. I am always looking for topics to discuss with them and looking for ways that get them to support their thinking during our discussions. "The goal of a Paideia Seminar is to deepen understanding of ideas, concepts, and values." [1] A Paideia Seminar is held in a fashion that is similar to a Socratic Seminar, the teacher acts as a facilitator and prompts the students with open-ended questions. During these seminars my students often give me one-word answers, or do not have valid reasons and evidence to support their thinking. I realized that a curriculum and discussions based in engineering where you must use evidence to support your ideas might be exactly what they needed to help them learn this crucial academic skill.

The more I thought about it, the more I realized that this curriculum would open many doors for my students beyond just discussions. Firstly, it teaches them about the field of engineering. My current students were originally unaware of what engineering was or what engineers do. This curriculum would introduce them to a field of work that they did not know of before. There are surveys which have been given that show that students from low income communities would create a better future for themselves if they took careers in

STEM fields, however, they must be introduced to such opportunities first. [2]

Most importantly, this type of thinking is extremely empowering for children. Engineering includes designing and building devices, processes, or structures which would solve specific problems. Students would need to think critically about a problem, figure out ways to solve the problem, and from there determine if this is a sustainable and cost-effective method. All of this inspires a new type of thinking which students are unfamiliar with. It shows them a new way to solve problems, use reasoning skills, and use evidence to support themselves. Overall, it is a powerful tool in which students can express themselves and their thinking.

Once I thought through what engineering was, and how this curriculum would supplement what I am already doing in my classroom, I realized that introducing engineering to elementary learners isn't crazy at all. Young students are naturally curious and eager learners who yearn to understand the world around them. I suddenly realized that this curriculum made perfect sense for my current students as well as my future students to come.

Rationale

While I knew that this curriculum would be extremely empowering for my students in the long term, I had to think about what would initially engage them in a topic which they had no context of to begin with. A lot of the time it is easier for first grade students to understand the world around them. They spend a lot of time during the year learning about their own community.

"In most 1st grade classrooms, students begin to explore their communities and the world around them more deeply, enhancing their research skills and general knowledge of the world around them" [3]. I knew that I would be able to use this to my advantage. One of the current "Grand Challenges" that engineers are concerned about is urban infrastructure. Since my students mostly live in New Haven, CT and all attend school in New Haven I knew that I would be able to get them thinking about how to make their community a better place to live. I did not want to phrase the problem in a way that made it seem like a city was a bad place to live. And I also wanted to use a more scientific term, so I decided that I would interest my students by asking them how they could make their community more sustainable.

In order to make this curriculum feasible I had to research and teach my students about certain ideas to help them think like an engineer. I would need to be able to explain to them what the field of environmental engineering is, and what the goal is for these types of engineers. I would also need to be able to explain what sustainability is in terms that a six-year-old would understand. My students would also need to learn about urban infrastructure, why is it built the way that it is? And why are many cities seeing problems with their infrastructure now? Many cities also experience what is known as the urban heat island effect, I would have to teach my class about the factors that make this occur. Lastly, before they could think of their own ways to make our community more sustainable they would need to know about types of alternative energy that are already in place. We will be learning about solar panels (which are installed on our roof at school), wind energy (since New Haven has a wind turbine), and how plants are currently being used to cool off other cities. Students would not only need to learn about how these types of energy work. But also, how they can help our climate in the future. Learning about and discussing these different topics would eventually help my students to think about their own ideas and create something to make our own community more sustainable.

Environmental Engineering

It is critically important to understand what engineering is and what it is not. Environmental engineering is not just explaining different types of alternative energy sources to your students and moving on. There is so much more creativity to it than that. “Throughout human history, engineering has driven the advance of civilization.” [4] Using creative and critical thinking, engineers think about how to solve current issues and predict the outcomes of these solutions. They choose to implement the solutions that are the most efficient, cost effective, and will last the longest. Many times, engineers have many ideas that never come to fruition. This is also an important lesson for young students to learn, not every idea is going to a be a good one. One must be able to determine which idea will have the best outcome in the long term.

Environmental engineering goes beyond this and takes into consideration the current state of our planet. “Environmental engineers use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. They are involved in efforts to improve recycling, waste disposal, public health, and water and air pollution control.” [5] Environmental engineers look at many different factors while they are considering solutions to implement. A lot of time and thought goes into calculated decisions; which is also an important lesson for young children who are normally impatient. They want things to work right away and the first time which is not always the case in engineering.

Engineering relies heavily on predictions. Often, young students are told that making prediction is making an educated guess. They are often told to use the sentence frame “If we do this, then this will happen”. An important distinction with engineering is that you are trying to predict an outcome before doing any of the building or in advance of an event. This changes the way that students would have to think about their predictions, they are not just thinking about what will happen in the experiment, but what the lasting impact would be. Another concept that goes along with predictability is mitigation. FEMA (Federal Emergency Management Agency) defines mitigation as “the effort to reduce loss of life and property by lessening the impact of disasters.” [6] Engineers predict the outcome of scenarios with mitigation in mind. The solution that they come up with must not cause any further harm than the original problem. For this reason alone, engineers think of many different solutions before implementing any of them. They must make sure that the outcome will not cause any further damage.

This type of thinking may be hard for students since time is a relatively new concept to them as well. However, this type of thinking can be related back to cause and effect which students do learn about in literacy. Students learn how causes and effect can impact the outcome of a story. Which means that they can apply this to thinking as an engineer would. Beyond just making predictions for what will happen in an experiment they must think for the long term. What will the lasting impact be? Will the solution cause further trouble or harm? If the answer to that question is yes, then it is not a good solution to implement.

Young students have the desire to always be correct the first time. Which is why thinking like an engineer may be challenging for them at the beginning. However, just because something is challenging does not mean that students should not try it. Students will feel empowered and successful when they develop a valid argument for why the solution that they come up with will be a sustainable one that will not cause further harm. Students have the ability to think like an engineer they just need to be given the tools and terminology to become successful. Students can also rely on using the engineering design process which is currently being used in STEM education in Massachusetts.

There is a cycle which engineers follow when they are trying to find a solution to a problem. The cycle is as follows: identify the problem, explore, design, create, test, improve. When initially giving your students a problem that they need to solve they might jump in right away and skip a lot of steps in the design process. It is important for them to learn about all the steps and learn why each step is critical to finding a lasting solution.

Step one is identifying the problem. Studies show that it is better to ask students a broad question rather than a narrow one. When students are asked a broader question, it gives every child regardless of ability the chance to answer it. However, if you ask a narrower question only certain students who have the proper knowledge to answer it will feel ready to. This leaves out an entire group of students who could potentially have the best solution. Engineering is inclusive; teaching STEM has been shown to increase vocabulary and language, technological knowledge, motor skills, graphing, visualization, improve social skills, and increase responsibility and personal growth. There are so many benefits to teaching STEM, especially using the engineering design process, so it does not make sense to leave out an entire group of students simply because the question that was asked was too narrow.

The next step is to explore solutions to the problem. This is where more than one idea is explored. Predictability, mitigation, and trial and error comes into play. The American Society of Civil Engineers states that “The ability to timely forecast accurate project outcomes is fundamental in an industry marked by endemic cost and schedule deviations” [7] . During this stage, engineers brainstorm and research different ideas to see which ideas would be considerable solutions and which would not. If the solution is going to cause more harm or be too costly, the idea may be rejected. This relates heavily to mitigation. Mitigation is considering the level of risk before the next potential problem happens. Engineers do not want their solution to be a quick fix that will not last, they want it to have longevity and be helpful long term. Engineers research the problem in order to determine its root causes, and to look for possible solutions. The more they know about the problem, the more potential solutions they can come up with. This phase of the engineering design cycle is critical because it ensure that the engineers thoroughly understand what they are working with. This step is based in thorough research of the topic.

The next phase of the cycle is arguably the most exciting part for young students; design. This part of the cycle allows students to be creative and plan out how they would solve the problem. Students can draw and write down their ideas in order to express themselves. It is also important for them to work on more than one idea. Trial and error is another critical component to engineering, not every idea is going to be the best answer to the problem. Thinking this way can be challenging for young students who always want to be right the first time. However, more ideas are better than one. And this gives them more opportunities to design their ideas. Trial and error is defined as the process of experimenting with various methods of doing something until one finds the most successful. A strong example of trial and error is a quote from Thomas Edison when he was inventing the lightbulb. ““I have not failed. I've just found 10,000 ways that won't work.” [8] Thomas Edison created many different prototypes before developing a working light bulb. Instead of giving up, he simply found out ways that would not bring his project success and he would begin a different approach. During this phase of the design process students can discuss their thoughts with one another, draw, and write them down. They are allowed to think as they please in a way which will solve a problem. Young children are natural problem solvers however, they are not always given the freedom to think this way. They should be encouraged to design their ideas fully, using details and evidence to why this solution would be a sustainable and cost-effective idea. This part of the process is important since it teaches children that they can plan for different things by drawing and using their words. It demonstrates that some problems need to be thought through fully. Drawing and writing can help them to deal with the complexity of the problem that they are

trying to solve.

The following step in the process is to create the prototype. This is where students would see their ideas come to life. Obviously not every child's idea is going to be used. However, it further propels the idea that the solution which is best in terms of cost, longevity, and sustainability is what would be implemented by actual environmental engineers. This also demonstrates how engineering can improve language, vocabulary, social skills, and personal growth. Students will have to look past the fact that they want their idea to best, if another one is in fact a better fit they will need to okay with it.

After creating the idea and seeing a prototype in real life it must be tested. Whatever the solution is, should be tested multiple times to ensure that everything is working as planned. Data should be taken to prove that the solution is working. The students can also oversee this aspect of the process as well. Keeping track of the data is another way to ensure that they are taking ownership of their design. This also shows students the importance of honesty and transparency when it comes to engineering and science. The National Society of Professional Engineers has stated that "As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare" [9] Since the welfare of the public is at stake, engineers must be honest and fair. If a solution is not turning out as expected, the engineers will not fake the data or lie to public. They note the problems that they are experiencing and move on to the next phase of the design process.

After the initial test, a redesign is required this is called the improve phase. The reason that this happens is so that students may fix any problems they found during the test phase. Sometimes a solution works just fine and only needs to be polished up before officially implementing it. Other times the whole solution may be redesigned. The data that is taken during the test phase helps to determine what changes, if any, need to be made. Students will need to analyze and interpret the data that they took in order to determine what should be done. They will have to use evidence to back up their reasoning and use their discussion skills to get their ideas across. Students should be well versed in their solution at this point, so their arguments should be valid and make sense.

Sometimes, the test and improve phase are repeated many times before the official solution is implemented. This is to ensure that data is accurate, the solution is cost effective as well as sustainable, and that it will help out the community for a long time.

This design process seems long and too much for young students to handle. However, elementary students have a natural curiosity and desire to solve problems. The design process is tailored to solving problems that have some complexity. This process is the perfect opportunity for them to explore these things in a constructive way. They will also be working on skills that are critical in language arts as well as mathematics to back up their ideas. This will make them stronger in all subjects as they move throughout their school and demonstrate practical usage of the skill they are learning.

Sustainability

Defining sustainability in terms that young students understand is also critically important for the success of this curriculum. Sustainability was defined in 1987 as “development that meets the needs of the present, without compromising the ability of future generations to meet their own needs.” [10] This language is not accessible for young school children and it needs to be explained in a way that they can understand and discuss. Sustainability can be explained to children as maintaining the world that we live in. Engineering has played a large role in maintaining and improving upon lifestyles since the industrial revolution. We have become accustomed to certain luxuries and lifestyles and would not want to harm the status of our communities by doing something that would drastically change these things. Sustainability is often brought up when thinking of environmental engineering because we want the planet to sustain life for many years to come. This is a concept that students can identify and relate with. Students can understand, comprehend, and discuss why taking care of the environment and world around them is important. They understand that they must do things such as recycle, participate in clean up days, and complete small tasks like shutting lights and water off when they are not using them to help the environment. We can push this one step further and ask students to create prototypes that make their own communities more sustainable. How can we make our society more sustainable for the future?

Renewable Energy

Renewable energy sources, or alternative energy sources are driven by climate change. The goal of using these types of energy sources is to reduce the emissions of greenhouse gases. Another benefit of using alternative energy sources is that they are renewable, meaning that they come from a source that does not run out. An increase of usage in these types of energies would help make our communities and world a more sustainable place.

Solar Energy

“As a source of energy, nothing matches the sun. It out-powers anything that human technology could ever produce. Only a small fraction of the sun’s power output strikes the Earth, but even that provides 10,000 times as much as all the commercial energy that humans use on the planet.” [11] As a renewable energy source it can consume and produce energy most commonly through solar energy panels. Such panels can be placed on rooftops, unused spaces, on pavement, and in parking lots. The use of such panels in cities with adequate sun hours can be quite efficient. Unfortunately, solar energy only accounts for 1% of energy that is used and consumed. Over 85% is still based in petroleum, natural gas, and coal. These types of energy sources are not renewable, and produce more toxic air emissions and greenhouse gasses, however, they are less expensive alternatives. [12] Solar energy’s current challenge is its price-tag. “Current solar cell designs require high-purity, and therefore expensive, materials, because impurities block the flow of electric charge.” [13] Solar energy can also be challenging to store. Other energy sources like oil, coal, and natural gases are already stored naturally which makes them easier to handle. Engineers are currently working on solutions to these challenges in order to make solar energy more prominent in our society. However, many urban and communities have already implemented them by placing solar panels on roofs of buildings with adequate sun hours. Since the United

States still relies heavily on fossil fuels we are behind the trend of using solar energy. Some countries such as Germany are leaders in using this type of energy source and solar energy accounts for nearly 7% of the electricity that they are generating. Not only do they install solar panels on rooftops but also have solar parks which collects solar power on a larger scale.

Wind Energy

Urban environments can place wind turbines in open green spaces and harness the wind that passes by. “At present, these energy resources, including wind power, are preferred around the world because they are both clean and renewable.” [14] Around the world communities are looking into wind energy as a renewable energy source since it is so clean. Unfortunately, wind energy faces a similar problem to solar energy. The cost and upkeep of wind power is also expensive. In some areas “Cost, technical concerns, public opposition and environmental problems are the causes of this low share.” [15] However in some places such as Montana wind energy is less expensive than other fossil fuels. This makes wind energy a much more attractive alternative energy source than others. Many countries are beginning to adopt and install this type of renewable energy despite the cost. “Wind energy is the fastest growing energy source in the world and wind power is one of the most widely used alternative sources of energy today.” [16] While many major countries such as Germany and China are implementing wind turbines to generate this type of renewable energy, there are many public concerns against it. “the environmental impacts of wind power as noise and visual effect, effects on animal and birds,.” [17] These impacts are causing the public to stop and think if wind turbines are the proper choice for their own communities.

The largest wind turbine in Connecticut is located in New Haven on the Quinnipiac River. The turbine converts kinetic energy provided by the wind into electricity. [18] This turbine is owned by the Phoenix Press which is in New Haven and is supposed to offset their electric bill by one third. There is enough wind in this area of New Haven to power the turbine and generate enough electricity to help their business. The electricity produced from this one single turbine helps them to produce goods for their clients. One turbine greatly helps their business. If one turbine can do that, imagine what an entire wind powered farm could do. There are such places in the United States where wind farms exist such as Iowa where they get 30% of their electricity from wind energy.

In addition to concerns of cost and environmental concerns, fossil fuels have a larger share of our provided energy since people started to use them as energy sources earlier. Fossil fuels work well currently and have worked well for many years. However, it is important to remember that these types of fossil fuels directly produce greenhouse gasses that are responsible for warming the planet. On the other hand, we will continue to have energy provided by the sun and energy harnessed from wind for a long time to come. For these reasons it is important to teach young children about the possibility of using alternative energy sources in the future; to teach them how and why these energy sources are more beneficial in the long run.

Urban Infrastructure

In an urban environment, the infrastructure includes everything that the city needs to sustain the community every day. The buildings, roads, sidewalks, transportation, electricity, and sewer systems all fall under the

umbrella labeled as infrastructure. Urban infrastructure is built to last for decades to centuries. This means that many cities were built a very long time ago and are now facing the repercussions. When constructing in urban environments, people tend to build with longevity and space in mind. They want to buildings to last for a long time and in order to be spatially efficient they are normally very tall. The majority of buildings in cities were built a long time ago, as a result they are now outdated. Most buildings in cities were built over a century ago and are now not performing to the best of their ability. “It is no secret that America’s infrastructure, along with that of many other countries, is aging and failing, and that funding has been insufficient to repair and replace it.” [19] The United States as well as many other countries across the globe face similar challenges with their urban infrastructure and have looked to environmental engineers to create sustainable solutions to these challenges. The biggest challenge of all is that the amount of people who live in cities is expected to double within the next thirty years. The largest population growth occurs within cities which puts a large strain on the infrastructure. Currently cities do not have the capacity to support this type of population growth. Engineers are looking for ways in which they can improve urban infrastructure in order to support this expected population increase.

Urban Heat Islands

Due to the materials used commonly in cities, urban environments often experience temperatures that are warmer than their surrounding suburban and rural environments. These common materials include concrete, bricks, and asphalt. These materials are known to trap heat; they have a high capacity for thermal storage. Overall, this is to blame for higher temperatures within cities compared to surrounding rural areas. The materials used to build the infrastructure traps the heat and makes the city warmer than suburban and rural areas that surround it. This impacts public health and the amount of energy used in cities. Since it is so much hotter, cities tend to use more energy and consequently spend more money in order to cool the urban environment. One current solution to the urban heat island effect is to increase the vegetation within the city itself. “urban vegetation has been widely adopted, common practices including urban lawns, green roofs (also known as “Eco roofs”), shade trees, and urban agriculture [17–19]. Urban vegetation, supplied with adequate soil water availability, is capable of reducing environmental temperature through the cooling effect of evapotranspiration.” [20] During evapotranspiration, water is transferred to the atmosphere by evaporation from the soil and transpiration from plants. The process produces a cooling effect associated with the change of state (latent heat of evaporation) of water from liquid to gas. This has led many cities all around the world to take a closer look at the benefits or urban farming.

In places such as Singapore they have constructed what are known as “supertrees”. These structures were constructed in order to create vertical gardens within the city. These vertical gardens provide shade and habitats for many different specifies. They also collect rainwater and support plant life. Structures such as these supertrees in Singapore greatly help to cool off cities and reduce the effects of the Urban Heat Island. Urban farming is a great potential solution to help cool down these hot urban environments.

Conclusion

Environmental engineers use many different types of science to guide their research on a project. They use mitigation, sustainability, and predictability to fully reason why their solution is going to be the best solution for the problem. Reasoning, evidence, and data are used to create valid arguments which support their ideas. Engineers must be honest and may try and fail many times before finding a solution that is going to work. All of these factors make environmental engineering the perfect introduction to STEM education for elementary learners.

Students must learn the background information on engineering and become well versed in the engineering design process. They must study and familiarize themselves with what the current problem is in urban infrastructure and why the urban heat island exists. They must learn about urban farming and alternative energy sources which are currently being used to help cities across the globe already. They can also research and learn more about other solutions that engineers are currently working on to make cities more sustainable.

Once they have become steeped in this STEM knowledge, they will be ready to put on their own engineering thinking caps and create solutions and prototypes for their own community. They will have the chance to interact with data and reasoning in ways that they never have before. Which is why I should have never been daunted by the idea of teaching environmental engineering to six-year-olds in the first place. They have the courage, curiosity, and desire to make their communities more sustainable, they just need to be given the opportunity to try it.

Classroom Activities

Activity One: Introduction to Environmental Engineering

Materials: The Lorax, poster paper to be used by the teacher, writing paper, writing instruments

Using Dr. Seuss's, The Lorax, the teacher will introduce the topics of what the environment is and how urbanization has changed much of what the world looks like. The final quote of this book is, "Unless someone like you cares a whole awful lot, nothing is going to get better. It's not." [21] The teacher can explain that there are people called environmental engineers who care a whole awful lot who are trying to fix some of the problems in the environment that people create and that in this new unit we get to act as if we are environmental engineers.

Using the poster paper students will list some of the environmental problems that occurred in the book due to urbanization and factorization. Some examples are loss of habitats, air pollution, water pollution, and destruction of natural resources. During this time it is also important to discuss that we still need to build things such as houses and cars, however can these things be done in a way that is more environmentally friendly?

After creating this list students will have a discussion on why we should work to protect our environment instead of doing things that harm it. The teacher can explain that environmental engineers often do research

on these topics to help them decide on how to help the environment.

To close the lesson, students will write about what environmental engineers are and what they do. Using the anchor chart list they will write about certain problems that they work on to help the environment.

Activity Two: Urban Heat Islands

Materials: Grassy area outside, concrete or brick area outside, paper, writing instruments, spray bottle with water, poster paper to be used by teacher.

Students and teacher will go outside to compare which is hotter; grassy areas or concrete and brick areas. Students will start out in the brick and concrete environment. They will discuss and write down the temperature and how they feel in this environment. Next they will move to a grassy area, once again they will discuss and write down how the temperature feels in this environment. If this is done on a dry, hot day the teacher may also want to bring a spray bottle with water in it outside. When the teacher sprays the water out of the bottle the students will experience the effects of evapotranspiration. If the temperature is hot enough, after the water is sprayed it will evaporate in the air. The students will feel cooler due to the droplets evaporating in the air. It is critical in this activity to ensure that the droplets are not landing on the students but actually changing states in the air.

Upon returning into the classroom students will compare and contrast the two environments. Which was hotter? Which was cooler? Why do you think the grass is cooler than the brick or concrete? If completing the evapotranspiration activity they can also discuss the results of the cooling effects that they experienced.

Students will discuss their findings as a group and write about how green, grassy areas of vegetation help to cool down the urban heat island effect. With the help of the teacher they will create an anchor chart which explains that urban environments which use certain materials in their construction are hotter than the areas that surround it. As well as the fact that vegetation has a cooling effect on these areas.

Activity Three: Wind Energy

Materials: Wind energy kit (car or light bulb or both), paper, writing instruments, poster paper to be used by teacher

Depending on the weather students will either be inside using their breath to create wind or go outside and use the natural wind energy. Using the wind energy kits students will use wind energy to either turn on a lightbulb or make a toy car drive. They will see firsthand that we can use an alternative energy source that is around us to make things go or turn things on. Students will actively track data on how much energy is needed to turn the light on or to make the car drive.

After the hands-on, exploration activity students will discuss what they learned about wind energy in this activity. They will use the data that they collected to support their findings during the discussion. With the help of the teacher students will create a poster so they can have a visual anchor in the classroom that explains what wind energy is and how we can harness and use what is already around us to power different things.

Activity Four: Solar Energy

Materials: Solar energy kit (powers a car, solar cell phone charger, or both), paper, writing utensils, poster

paper to be used by teacher

Similarly, to the wind energy activity, students will engage in a hands-on activity where they will either charge a phone battery or power a toy car using solar energy provided by the sun. Students will actively track data and see how long it takes for these things to charge or drive depending on how much sunlight they are getting.

Afterwards, students will have a discussion where they will use their data to discuss and support what they learned in this activity. With help of the teacher the class will create an anchor chart using key terms and vocabulary which will help them to explain solar energy and how we can use it to power things around us. Controls can be used in this experiment to bring it to the next level. For example, using two solar panels with one in direct sunlight and one blocked from the sun. This would show the students that the solar panel needs the sun to produce power, this adds an element of critical thinking to this experiment.

Activity Five: Designing a more sustainable community

Materials: Class made anchor charts, poster paper, writing paper, drawing and writing utensils.

After learning about different types of alternative energies, green city models, the urban heat island effect, and how environmental engineers are trying to make cities more sustainable, the students will be able to take what they have learned from the whole unit so far and design a solution to the original broad question of "how can we make our community more sustainable?"

We will come back to the original broad question from the beginning of our unit and we will reassess all the data and information that we have tracked about the urban heat island effect, urban farming, wind energy, and solar energy using our class anchor charts. From here the students will decide what change they would implement in our community to make it more sustainable.

Students will draw and write about their design. This is the third step in the engineering design process, students should be encouraged to explore all their options and even work on more than one design. They can draw, write, and discuss what their potential solution would be.

In this activity there is no "right or wrong" answer, there are only potential solutions. Students should be using the class anchor charts and data from the previous activities to help them design. However, they are acting as environmental engineers and should be given the freedom to explore their ideas as they desire to. After an adequate amount of time designing students will share their ideas with the class.

Implementing District Standards (Next Generation Science Standards)

The standard that I have aligned my unit to is as follows:

K-2-ETS1-1 Engineering Design: Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. [22]

Using the engineering design process students will explore the topics of urban infrastructure and the urban heat island effect. They will participate in hands on activities about how vegetation can cool off urban environments and how solar and wind energy work. They can use these activities to ask questions, make observations, and gather information. Over the course of the unit students will go through the engineering design process in order to come up with solutions to the problem “how can we make our community more sustainable?” Using the design process students will get the chance to create a change which would improve the city that they live in.

Annotated List of Resources

For teachers

There are several articles and web-based resources that I accessed in order to learn more background on certain topics. These articles and websites are as follows:

Douglas, K. Anna, and Johannes Strobel. "Hopes and Goals Survey for Use in STEM Elementary Education." International Journal of Technology and Design Education 25, no. 2 (08, 2014): 245-59. doi:10.1007/s10798-014-9277-9.: This survey was given to a group of students in urban environments. It dealt with different questions and the responses that these students gave. This article had a lot of insight on why focusing on STEM in urban environments is critically important.

Ferrara, Rosario. "The Smart City and the Green Economy in Europe: A Critical Approach." *Energies* 8, no. 6 (05, 2015): 4724-734. doi:10.3390/en8064724.: This article focuses on the vertical gardens in Singapore. These vertical gardens are called “Supertrees”. These supertrees help the environment in the city in many ways, they provide shelter and habitats for certain species and also help to cool down the city and reduce the effects of the Urban Heat Island. This article supports the notion that vegetation helps to cool urban environments.

Kabul Tarihi, Makale. “Turkey’s Foreign Dependence on Energy and Wind Power as an Alternative Energy Resource.” *U.U. International Journal of Social Inquiry* 9 no. 2 (2016) 1-31. This article discusses how Turkey is growing increasingly dependent on wind energy as an alternative energy source. It explains the reasoning behind this decision as well as the costs, benefits, and how they are harnessing this energy.

Wang, Zhi-Hua, Chao Fan, Soe W. Myint, and Chenghao Wang. "Size Matters: What Are the Characteristic Source Areas for Urban Planning Strategies?" *Plos One* 11, no. 11 (11, 2016). doi:10.1371/journal.pone.0165726. : This article contained information about the Urban Heat Island effect and what this means for urban environments. It also contained a lot of useful information about urban infrastructure and why environmental engineers are needed in these areas.

Watt, Anneliese. "NAE Grand Challenges for Engineering: Rhetorical Analysis of Grand Challenges Website." *2012 IEEE International Professional Communication Conference* , 10 2012. doi:10.1109/ipcc.2012.6408651. : This article was critically important while I was developing this curriculum. It highlights what current engineers determine to be the biggest challenges that they should be focusing on. This article discusses challenges such as urban infrastructure and alternative energy sources. This was my “go-to” source when I need clarification on a specific topic.

"What Does Sustainability Mean for Children?" UNICEF UK. May 25, 2017. https://www.unicef.org.uk/define-sustainability-children/.: This website helps to describe what sustainability is in terms that elementary students will be able to comprehend and be able to explain themselves when discussing this unit.

"What Is Mitigation?" What Is Disaster Assistance? | FEMA.gov

https://www.fema.gov/what-mitigation. : Mitigation can be a tricky concept to teach to children, this website helped me to develop a deeper meaning for what mitigation is and how I could explain it to my students in terms that they would be able to understand and use on their own during discussions.

For students

The Lorax by Dr. Seuss: This book can be read initially by the teacher, but the students can access it throughout the unit. This is a great text that introduces urbanization and factorization. It demonstrates what happens when we do not take care of our environment. It can also be used to demonstrate why we must make our own communities more sustainable.

Materials for hands on activities

Solar Energy Kits: These hands-on kits can be ordered online through a retailer such as Amazon. There is a large variety of kits and what they use solar energy to power. You should pick the kit that you think will most engage your students in the learning. I decided to use a solar powered car and a solar powered iPhone charger. I felt that these two kits demonstrated that we can use solar energy in different ways however, driving and charging a phone are very important to young children so I felt that they would invest in these kits the most.

Wind Energy Kits: Similarly, to the solar energy kits, wind energy kits can also be ordered online. They also have a variety of choices to pick from. Again, I urge you to pick options that will engage your students the most while demonstrating that we are using wind energy to power these objects. I chose to use a wind powered car as well as a wind powered light bulb. I again decided I wanted to use these kits because I felt my students would be most invested in interested in them.

Endnotes

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