Sustainable Materials for Energy Efficient Homes: A Problem-Based Unit

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Placement

I teach at Dickinson High School in Wilmington, DE in a two-year-old International Baccalaureate Middle Years Program. The program is located in a wing of Dickinson High School and was created as an extension to the International Baccalaureate Diploma Program, exclusively for grades eleven and twelve. This program has existed in the school for over six years. To encourage more students to attend the Diploma Program, the Middle Years Program was created to serve as an entry point for students across New Castle County. Last year the MYP included grades six, seven, eight and nine, and is expanding to include tenth grade this upcoming school year, which will create a continuous sixth through twelfth grade IB program at Dickinson. Due to the success of the program, we are transitioning from approximately 240 students to a maximum of 300 sixth, seventh, and eighth graders in the middle school section.

To become enrolled in the program, the students apply and a few stipulations apply. To be eligible the students must be motivated, read on grade level, and have a teacher recommendation. This year, the third year of the program, I will be teaching sixth and seventh grade Individuals and Societies, which is an integrated social studies course. The curriculum is based on the Delaware Recommended Curriculum for social studies with enhancements made to the units to have more of an international basis and universal application. This year, with the expansion, I will be teaching four fifty-minute sections of seventh and two sections of sixth grade Individuals and Societies.

An important part of the IB program is understanding the world around us. Even though the school is diverse and students live in a diverse region, the students usually have only a surface-level understanding of different cultures within the United States and around the world. They need experiences to encourage cultural study, and to see the ways in which humans are very similar even though on the outside they seem to be very different. I'm hoping to use the topic of material science to offer the students opportunities to find the commonality between human cultures by looking at the ways different societies construct their cities and towns.

The students in the MYP are hard-working and highly engaged. They go above and beyond the expectations when completing assignments and in interactions with their peers. This sets the bar high for development of highly-engaging lessons and learning experiences, as the students are hungry for knowledge and continuously push themselves

and me! Some students, however, are afraid to take risks. They need to be encouraged to push themselves in trying something unknown or taking a more challenging path to learn in a new way, which may not be as easily accessed or apparent to them. This is where my role as an educator becomes the most important. I want to teach the students to use alternative methods and to be creative in learning.

Rationale

As a result of this seminar I hope to further develop a portion of a seventh-grade unit on sustainability and green urban development. The Delaware Recommended Curriculum, Green Cities, briefly discusses the history and development of cities in America beginning with the Jamestown colony and ending in the cities of the future. Topics of study include the green space movement, city planning, and high-rise farming. The unit is very interesting but lacks the depth that my students demand. In teaching the unit last year, I ended up supplementing the unit on the fly based on the interests of my students. I would like to learn more about sustainability and the green building materials that allow cities to meet the needs of their people so that I can better address the questions of my students.

Unit Overview

This unit will delve into several aspects of home design that relates to the material science theme of this seminar. As a hook to the unit, the students will receive a letter from an urban development company informing them that they've won a plot of land but there are strings attached. To keep the land, they have to design a sustainable and energy efficient home. They will be challenged to think like a materials science researcher, architect, homeowner, and builder. This activity will help the students to see the challenges in sustainable and efficient home design and understand the multiple perspectives on appropriate materials for building a home.

Next, using a problem-based learning format, the students will be led through a guided investigation of different building materials and face the challenge of selecting appropriate materials to build a home in region with a challenging climate. By the end of the unit, the students will be able to provide a rationale for their selection of building materials based on the properties of the materials.

As a culminating activity, the students will present their home design along with their rationale for choosing particular building materials. They will play the role of a home developer and will need to identify sustainable building principles to make recommendations as to the materials and resources that would be necessary to build their sustainable and energy efficient homes.

Background Information

Introduction

The materials around us, define us. Mark Miodownik in his book, *Stuff Matters*, explains, "The material world is not just a display of technology and culture, it is part of us. We invented it, and in turn it makes us who we are."[1] He believes that even small changes in the materials we use can result in larger changes in human behavior. New materials and technology actually change the ways in which people live and think. Understanding materials and being on the cutting edge of technology gave early civilizations and empires an advantage over their rivals. The Romans, for example, had developed steel nails that allowed them to build solid, lasting structures. These improved building projects (thanks to the steel nails) is one factor that allowed their population to grow and flourish. Keeping steel nails for themselves was a priority for the Romans as they recognized the power of this material/technology. At one point in Roman history, the Romans were threatened by the Celts and decided to abandon one of their forts rather than continue to fight a losing battle. Before retreating, the Romans removed and buried all of the steel nails at their outpost so the Celts would not learn of their value.[2] The materials we can access and our ability to use them can define the advantages and limitations of human societies.

Sustainability and the Materials Science Field

Materials science, sustainability, and environmental issues are closely related. In particular, the materials science field works to develop new materials based on human needs and wants. Researchers in the materials sciences conduct investigations to gain an understanding of how materials behave under different conditions. Chemists form the backbone of the materials science field as they work to understand the ways the unique structures of the Earth's elements influence the way they perform. Chemists then manipulate and tailor specific properties of elements to meet particular societal needs. These types of investigations and materials development can assist in advancing sustainability in the resources used to build homes.[3] Diran Apelian of the Worcester Polytechnic Institute explains, "Sustainable development is perhaps the most pressing issue of the 21st century. At the same time, it is a remarkable opportunity for practitioners of materials science and engineering (MSE), as many of the approaches to address these challenges are materials-centric."[4]

The challenges that many researchers are trying to address can improve the materials that we use to build our neighborhoods and cities. An important goal in the materials science field is capturing greenhouse gases and converting them into higher value products such as feedstock chemicals and other solids. Materials science researchers are also looking into the treatment of water by removing contaminants from the water and remediating natural surfaces. Finally, materials science researchers are studying the

surface chemistry of environmental materials like water and natural semiconducting materials.[5] Adapting materials in these ways can help us to meet the goals of our society.

Sustainable Homes

Many countries are confronting the challenge of producing housing that is sustainable and energy efficient. Governments across the globe are working to improve their citizens' standard of living in the face of challenges posed by pollution, climate change, and natural disasters. These problems are pressing, and many urban areas are experiencing population growth that places higher demands on natural resources and the environment. Housing booms such as those taking place in many regions around the globe, require large amounts of energy to be consumed in the construction of homes, as does their subsequent occupation and use.[6] Builders and homeowners can lessen these negative impacts by making wise decisions in the materials they use to build their homes. Diran Apelian in his article, *Materials Science and Engineering's Pivotal Role in Sustainable Development for the 21st Century* explains, "…whereas population is growing at an average rate of 1.4% a year, energy needs are growing at an average rate of 1.7%." the problem seems to be getting worse as "many developing countries seek to emulate the developed nations and their energy consumption habits. Such consumption of energy is not sustainable."[7] This population growth puts a large burden on the energy industry and the population continues to grow and seek a higher standard of living.

Our dependence on energy has caused an increase in carbon emissions and pollution as well as an overall decrease in air quality. Living in regions with high levels of air pollution have been known to cause respiratory illnesses and cardio vascular disease.[8] According to D. Bradley Rowe of the Michigan State University Department of Agriculture, "Nearly one-quarter of the people in the United States live where there are unhealthful short-term levels of particle pollution, while roughly one in ten people live where there are unhealthful levels year-round."[9] The goal of sustainable design is to reduce these types of negative environmental impacts and improve the surrounding environment for residents.[10] Many sustainable home development plans work to reduce carbon dioxide emissions. This can be achieved in the housing industry by working to improve the building materials themselves, energy usage and type, ventilation, water, architecture, and construction.[11]

For a home to be considered sustainable it must benefit the current homeowner without damaging or destroying the environment for future generations to come. The core of sustainable building involves using caution and advanced planning to maximize the efficient use of scarce natural resources. Kamand M. Roufechaei in the *Journal of Cleaner Energy* expressed, "Sustainable housing development is equally about building a society in which a proper balance is created between environmental, social, and economic objectives."[12] Saudi Arabia is creating a building sector that constructs sustainable and energy efficient homes. To help meet their goals, a framework was developed to express

the specific goals of sustainability and methods for reducing carbon emissions.[13] The framework provides key strategies and materials necessary for sustainable home layout, structure, window design, roofing, energy, and water. The framework will serve as a backbone for the students to design a sustainable and energy efficient home.

Building Fabric

The core of sustainable housing lies in the design of the home and the materials used to create it, which is known as the building fabric. The building fabric consists of the main structure of the home that includes the floor slabs, walls, windows, roof, and doors. The Alternative Technology Association believes that, "Sustainable home design is really just common sense." First, they suggest using passive design, and designing for the climate. This means that the home optimizes the existing climatic conditions and uses natural heating and cooling to keep the home comfortable year-round. To maximize the passive design potential, it is advised to orient the home correctly. Orientation can assist in maximizing or reducing the sun's heat depending on the season. In addition to the sun's heat, local wind patterns can be assessed to design a home that uses breezes to provide natural ventilation throughout the home. Orienting the home properly will significantly reduce the reliance on heating and cooling systems, which will save money and protect the environment.[14]

Secondly, the home's size matters. A smaller home is easier to heat and cool, which reduces energy demands and costs.[15] Home designs that are simple tend to be easier to insulate. Simple designs are ones that reduce the number of joints and use large panel construction systems. The emphasis in designing the overall home's structure should be placed on making the entire home leak proof.[16]

Thirdly, the home should be insulated wisely. Insulation prevents heat flow in and out of the structure depending on the season. With proper insulation, the home will retain heated or cooled air and reduce the reliance on energy sources.[17] Houses need to be airtight to prevent drafts and high or low indoor humidity. When homes are built with airtightness taken into consideration, heating and air conditioning costs can be reduced significantly.[18] In *Home Sweet Home,* Allen Zimmerman explains, "uncontrolled air leakage can represent up to 50 percent of the annual heat gain and loss in a house," and "up to 95 percent of the moisture movement into house walls and ceilings is due to moisture hitchhiking as part of the air leaking into these spaces (as opposed to vapor diffusion through surface covering materials)."[19] Proper insulation techniques and materials can save the homeowner lots of money on energy costs, and add to the overall comfort of the home.

Fourthly, builders should work to use sustainable materials and reduce waste. The Alternative Technology Association cautions, "If you build your house with poorly chosen materials, their embodied energy could diminish or cancel out the benefits of

years of sustainable living." The embodied energy of housing materials is calculated through a rating system where the environmental costs of extraction, processing, manufacture and delivery of building materials to the building site are analyzed to determine the energy efficiency of the materials themselves. When possible, the builder should use natural materials that can be obtained locally and consider the transportation costs involved in retrieving materials outside of the region. Recycled or recyclable materials should be used as much as possible to minimize the negative impacts to the environment.[20]

Finally, window placement is critical. If not glazed and installed properly, windows can allow warm air to escape in the winter and seep in during the summer. To prevent this, windows should be double glazed, or created using two panes of glass with an insulating vacuum layer between them. Also, the number of windows and their locations are important to the airtightness and airflow options of the home. The Alternative Technology Association suggests that "the total window area of your home or a room should be less than 25% of the total floor area," and "most windows should be located on a home's north side where good solar access is easiest to manage."[21] Since windows and doors pose a challenge in creating an airtight home, window selection should be based on the potential for airtightness, thermal performance, transparency, and sustainability.[22]

Roofing

Another important area of sustainable and energy efficient design is roofing. The tenants of sustainable roofing by Thomas W. Hutchinson and Keith Roberts in their report *Towards Sustainable Roofing* are, "broadly grouped under three key areas of improvement: preservation of the environment, conservation of energy, and extending the life of the roof." The authors explain that these tenets are fluid and open to adaptation and change as new technology and methods are introduced.[23]

Firstly, preservation of the environment involves the use of roofing materials that are recycled and/or can be reused. Preservation of the environment should not be limited to just the building process, it should take into consideration the life cycle of the roof to include the materials that are used to build the roof and the byproducts that exist as the roof is destroyed. Roofing materials should not pose a hazard to the environment when being collected or destroyed. An excellent example of roofing materials that benefit the environment would be a green roof, which is a roof covered in vegetation. Green roofs offset the environmental impact of a home and help to preserve the natural environment.[24] D. Bradley Rowe in *Green Roofs as a Means of Pollution Abatement* explains how great the impact could be, "…rooftops which often comprise 40-50% of the impermeable area in an urban area provide an opportunity to replace impermeable surfaces with vegetation."[25] Green roofs help to offset the vegetation that was removed for homes and buildings, reduce pollution, reduce water runoff, and improve water

quality. Green roofs work by reducing carbon dioxide in the atmosphere which helps to sustain the ecosystem and improves the life of the roof.[26]

The second key area, conserving energy, is achieved by taking into consideration the home location's climate when selecting materials and designing the roof itself. Builders can use the environment and sustainable design principles to reduce energy needs.[27] For example, the top floor of a home requires more air conditioning to stay cool, especially in hotter climates, so builders can use methods for shading the roof to help reduce the demand for energy.[28] The vegetation on a green roof can provide shade and an overall cooling effect on the home or building. This shading and cooling can reduce the amount of air-conditioning required to cool the home.[29]

Lastly, extending the lifespan of the roof is achieved by appropriate monitoring and maintenance during the building process and beyond. Monitoring and maintenance of drainage systems, identifying and fixing weak spots, and keeping the roof in working condition will help the roof to last longer.[30] Green roofs last longer as compared to traditional roofs since the materials are protected from solar radiation and rainfall and they limit the vast temperature differences between night and day.[31] D. Bradley Rowe explains, "The mechanical lifespan of a typical conventional roof is approximately 20 years. When these roofs are replaced, the old roofing materials must be removed, transported, and will likely be placed in a landfill where they not only take up space, but may also leach pollutants into the environment. On the other hand, green roofs are estimated to last 45 years or longer in terms of mechanical lifespan."[32] The lifespan of a roof is highly dependent on the materials that are selected during the home design process.

Energy

The choice of energy source for a home impacts not only the homeowner but the surrounding area as well. Diran Apelian states, "Today about 80% of the world's energy comes from fossil fuels. In North America, energy generation is responsible for 40% of greenhouse gas emissions."[33] Caitlin McGee in *Your Home: Australia's Guide to Environmentally Sustainable Homes* states, "Climate change is arguably the greatest challenge faced by humanity." To combat this challenge, they presented important goals for energy usage in homes.[34] These goals include reducing carbon dioxide emissions, managing energy supply, reducing energy demand through energy efficient home design, and investing in renewable energy. The transition from fossil fuel based energy sources to renewable, clean sources has not been as fast as many would have hoped. The majority of homeowners aren't demanding renewable energy sources for their homes because they don't feel a sense of urgency in reducing their individual carbon footprint or they may view renewable energy sources as being too expensive and/or complex. These viewpoints, though, are short-sighted. Allen Zimmerman of Ohio State University states, "It is also important to realize that an emphasis solely on initial costs or payback periods

fails to take into account the many other benefits of energy-efficient homes. At the societal level, an energy efficient house has considerable value in that energy and material resources are conserved and pollution is reduced."[35] As discussed earlier, when designing homes and buildings the land and climate must be taken into consideration so adaptations can be made to ensure the structure is energy efficient.[36]

The first goal of energy efficiency is for people to use sources of energy that reduce greenhouse gas emissions that contribute to climate change and sea level rise.[37] Builders should use renewable sources of energy that have the ability to send surplus energy back to the grid. The most common renewable sources of energy for homes are photovoltaics, wind turbines, biomass, and combined heat and power (CHP). Regardless of the energy source, the systems must not be overly expensive and should be easy to maintain to ensure homeowners buy in.[38]

Secondly, renewable energy sources should "manage demand and maintain security of supplies."[39] Diran Apelian cautions, "…with current technology, renewable sources of energy (such as hydroelectricity, biofuels, and geothermal energy) will not be sufficient to meet the energy consumption needs of the world. Nevertheless, materials developments could make solar power, biofuels, and wind power into increasingly important resources."[40] Advancements in this area are being made at an accelerated rate. Our current power grids are able to distribute power from the power company to homes and from homes back to the power company based on demand. These flows allow for power to be used more efficiently and reduce waste. Under this system, power can be scaled up and down based on the usage and energy generation of the home.[41]

Thirdly, energy use should be minimized by building homes that are smaller in size and highly insulated. Homeowners should also "behave in a way that focuses on energy conservation." This goal may rely on a cultural shift for many people that grew up in a society that values large homes and using limitless amounts of energy around the house. An example of conservation-minded behavior would be homeowners opting to have sensors on heating and cooling units and lights that can turn on and off depending on the usage of the room.[42] To conserve energy, unnecessary spaces in the home should be reduced. For example, areas like formal living and dining rooms and guest rooms that are used infrequently could be significantly reduced in size or removed from the home design entirely. The sizes of rooms throughout the home can be reduced as well. Rooms that aren't used as often should be on the second floor where rooms that are high usage should be on the ground floor to reduce the demand for heating and cooling.[43] Dividing the home into a system of zones will allow for multiple heating and cooling units that can be more closely controlled for the microclimatic conditions in various parts of the home. Units can be turned up and down on an as needed basis.[44]

Lastly, homeowners should invest in renewable energy for heating and cooling, as well as heating water and cooking. The up-front costs for renewable energy equipment is

almost always higher than fossil fuel based systems but this cost will be offset as renewable sources of energy have low running costs.[45] Continuing this type of work in the materials science industry will help to make renewable energy goals a reality.

Water

Finally, water usage must be explored to build a sustainable and energy efficient home. Chris Glaze and Linda McKeown suggest two main goals for sustainable water usage for homeowners in their article, *The Code for Sustainable Homes*. Firstly, the quantity of water consumed should be reduced. Reduction of water usage can save on energy and lessen the impact on the environment. Water usage in the home can be minimized by simple means like controlling the flow rate of showers and sinks or by more complex means such as installing a water monitoring system. Many of these systems can be controlled using an app that alerts the user when there is an unusual amount of water being used or if there is a potential leak in the system. Another way to reduce waste is to maintain the pipework inside the home to ensure that leaks minimized.[46] Water reduction is not just limited to the inside of the home, there are numerous opportunities for homeowners to reduce their water usage in their lawns and gardens. Caitlin McGee of *Your Home: Australia's Guide to Environmentally Sustainable Homes*, explains that landscaping decisions should be based on the climate and native plants. Using native plants will be best suited for the environment and won't require excessive amounts of water or fertilizers. A great option for homeowners is to use collected rainwater as a source of water for lawns and landscaping.[47] For collected rainwater to be a feasible solution for homeowners, capacity is the main concern in selecting the appropriate materials and system. The system must be designed to hold enough water to cover the homeowner's needs even in times of low rainfall and drought.[48]

Secondly, water quality should be improved by managing storm water and wastewater. Caitlin McGee further explains, "At present potable (drinking) water is used for practically everything in the house and garden. We are literally flushing our drinking water down the toilet!" Wastewater from household usage can be reused for purposes in and out of the home. Water reuse is categorized based on the water quality: greywater and blackwater. Greywater is the waste from almost all household activities except for the septic system, water from the septic system is called blackwater. Greywater can be used for landscaping purposes and can even be reused in the home if it is properly treated.[49] Capturing rain water involves a few processes to ensure the water is potable. When collecting rainwater from a dry roof surface, there may be a biological residue such as algae or fungal growth, tree shade caused moss, and mold. Blackwater recycling systems are allowing large buildings to process and reuse blackwater, or sewage. The processed blackwater is used for the nonpotable needs of the building, a transition from blackwater to greywater. The greywater can be used in irrigation systems, plumbing systems, and in outdoor cleaning projects. For single-family homes blackwater recycling systems are too expensive and difficult to maintain but for large businesses and apartment

complexes, the expenses to install and maintain the system can be offset by the savings due to the amount of water that can be reused.

Sustainable Design and the Future

Building and urban development has been shown to cause negative impacts on the environment and contributes significantly to climate change. Consideration for the environment must involve using natural resources efficiently, and preventing the senseless destruction of environments. It is difficult to determine how natural resources and the environment will be impacted by our building projects. According to Kamand M. Roufechaei in the *Journal of Cleaner Energy*, "Although builders have little influence over the extraction of natural resources, they can help discourage this activity by demanding fewer non-renewable natural resources, more recycled materials, and the efficient use of energy and mineral resources."[50] For example, the soil needs to be protected from harmful chemicals as well as soil erosion and the contamination of water due to construction and building sites. This is an instance where the builder and buyer can influence the market by demanding products that consider, "renewable energy, energy efficiency, water efficiency, ecology, conservation, material efficiency, air pollution, pollution control, indoor environmental quality, sustainable site and land utilization and management." Consumers can influence these positive changes that they want to see as our society moves toward more sustainable housing.[51]

The movement to sustainable and energy efficient housing cannot exist without incentives. Joan Fitzgerald, author of *Emerald Cities: Urban Stability and Economic Development*, believes that we should look at movements towards sustainability as an opportunity to generate economic activity. She states, "The opportunity for linking sustainability and economic development is real. But there are many challenges. Cities cannot solve the climate crisis without international treaties and national policies to support them."[52] Governmental economic incentives could include tax breaks for homeowners who invest in renewable energy for their homes, savings for a reduction of energy usage during peak demand periods, providing assistance to manufacturers to retool to meet the demands for new energy efficient technologies, making standards for new building projects, and providing grants for city governments to improve upon the existing infrastructure.

Appropriate design can allow businesses to be more profitable and increase worker productivity. Having a plan for sustainability and a common goal can have a positive impact on the economy or a country. As homeowners move to be more sustainable, the demand for sustainable and energy efficient building materials will increase. Current business owners can increase demand by using sustainable and renewable building materials to meet the needs of a changing community.[53] Diran Apelian explains, "With increasing world population, the materials research community has an opportunity to make a major impact by developing novel construction materials that are environmentally

benign, energy-efficient, and affordable. Shelter needs for the world's population require novel material solutions as well as novel housing designs."[54] Leslie Paul Thiele in her book *What is Sustainability?* explains that a movement to sustainability takes more than just measures to improve our society, environment, and economy. She states, "By insisting on cultural creativity as a fourth component of sustainability, we underline the fact that our practices, relationships, and institutions have to initiate and respond to change if they want to endure for long. Sustainability demands imagination and innovation."[55]

Teaching Strategies

Problem-Based Learning

The unit is designed to be a problem-based unit on sustainability and energy efficient home design. A problem-based learning activity, or PBL, is an activity in which the students work to solve problems (usually realistic problems) related to a specific discipline. These learning experiences help to build the students' skills and confidence in seeking and communicating solutions to complex real-world problems. PBL helps students to delve deeply into a problem and organize a system to track what they already know, and what they need to know to reach a solution. This process helps students to be better self-directed learners.[56] PBL causes a shift in the role of the teacher as most of the learning is directed by the students. The instructor plays the role of a coach, leading the students and encouraging them to ask questions, seek the answer to their questions, and encourage the students to push through difficulties faced along the way. For students new to the PBL process, the teacher will also need to model the thought processes necessary to develop a solution to the problem. A classroom environment that fosters creativity, risk-taking, collaboration, and brainstorming must be developed and maintained for this type of learning to occur.[57]

When designing a PBL unit, the design of the problem itself is important for the unit's success. The initial problem should be "ill structured" meaning that the students can answer the question in a variety of ways. The problem should allow for creative problem solving and critical thinking. The problem should be similar to what experts and professionals in the field would encounter. Just as a professional would seek various methods for solving the problems they are tasked with solving, the students should be encouraged to think like a historian, city planner, economist, medical professional, senator, etc.[58]

"Ill structured" problems are incomplete and require more information than what is initially presented to be solved. The problem generally morphs and changes as the students research aspects of the problem's core concepts. These "ill structured" problems "prevent the students from knowing that they've made the "right" decision."[59] The instructor introduces the "ill structured" problem and the students generate a list of what

is known. This list should be on a poster, white board, or shared Google Doc so all students have access to it. The list should be updated and modified as the students learn more through their research, and as they work to solve the problem. Next, the students will generate another list; this time they will list the questions that need to be answered in order to solve the problem. This list of questions should be revisited daily to try to answer them or seek methods and assign the students responsible for answering the questions. The students will come up with a problem statement after dissecting the problem and generating questions. They will revisit the problem statement daily to revise and refine exactly what the problem requires them to do.[60]

Solutions to the problem can take many forms in most PBL units, the students present their solution to their classmates in a role-playing format or scenario. Depending on the topic and theme of the problem, the students could present to a mock county council, town hall, school board, UN council member, principal, etc. The strengths and weaknesses of the presentations should be discussed as a class and in some cases, a winner may be selected.[61]

Role Play

Role play is an important part of a PBL unit. Before beginning the activities, the students will be put into groups of three to four representing design teams. Each team will have delegated roles including the Project Manager, Senior Architect, Research Project Coordinator, and Construction Project Manager. The student playing the role of the Project Manager will be responsible for reporting to the president, making sure that the design team meets deadlines, delegating responsibility to the team, and confirming that documents meet the official rules and standards. The Senior Architect will be responsible for ensuring that the building materials meet the sustainability and energy efficiency goals of SEEC, sharing their home design vision, and taking the lead in choices related to meeting the needs of the potential homeowner. The Research Project Coordinator will be responsible for acting as a mentor to the design team to assist with the research process and overseeing and managing the collection of information. The Construction Project Manager will be responsible for ensuring the project is completed according to the budget and finalizing the selection of building materials to be sure they meet the sustainability and energy efficiency goals of SEEC. The teacher will play the role of the company's President who is responsible for overseeing all of the design teams. After receiving the entry document and corresponding contract during the first activity, the students will have time to assign roles and create an identity for their design teams to enhance the role play aspect of the unit.

Two-Minute Interview

For the purposes of this unit, the two-minute interview approach will be used to help the students refine their proposed solution to the problem by obtaining feedback from their

classmates. To set up the “interviews” the desks and chairs will be moved into two long rows so that students will be able to face one another. The students will be given two minutes to share their summarized solution to the problem with the interviewer. Then the interviewer will have one minute to ask questions. Finally, the interviewer will have one minute to provide feedback. This process will be repeated five times and then the interviewers and interviewees will switch roles and the process will begin again. After obtaining feedback, the groups will reconvene to discuss the feedback they obtained. They will be encouraged to develop a plan for revising their work based on the feedback obtained during the interview.[62]

Activities

Activity 1: Learning about the Problem

Entry Document: Letter from Gloria Higgins of SEEC

To begin the unit the students should be divided into groups of three or four students representing design teams that work for a design firm led by the teacher who will play the role of the company’s President. As this lesson progresses, the students will be assigned roles and given areas of focus for their particular job. The students will also receive documents from SEEC, the Sustainability and Energy Efficiency Commission, and begin to determine what they know and need to know about the problem, as well as develop an initial statement of the problem.

Without having any prior knowledge of the unit, the students will receive the letter below from Gloria Higgins, director of SEEC, informing them of a plot of land their design team has won. To keep this prize, they must design a sustainable and energy efficient home according to the official rules that will be distributed at a later date.

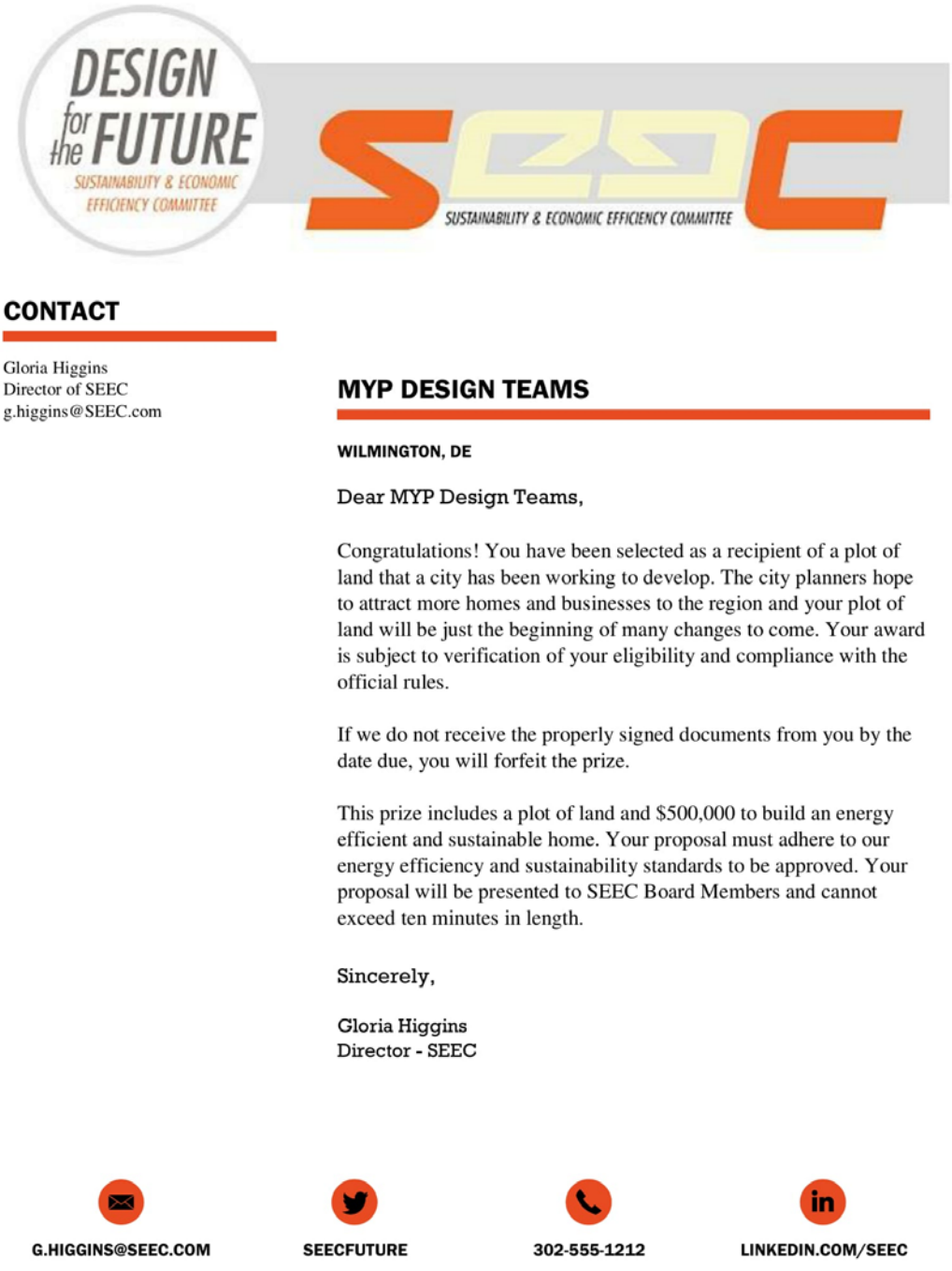

Figure 1: Entry Document: Letter from Gloria Higgins of SEEC

After reading the letter, the teacher will model the process of generating a list of the information that is known from the letter. This process will be repeated for each document that the design teams receive. These lists ensure that the students thoroughly read the document and are beginning to understand the problem. Here is what the list will most likely include:

- We won a plot of land.
- We must follow the official rules.
- We must turn in documents by the date due or will not receive prize.
- The prize also includes $500, 000 to be used on the building of a home.
- We must present our housing design.
- We need to follow the sustainability and energy standards.

Next, the students will generate a list of questions to describe what they need to know in order to complete the task outlined in the letter. Their questions should include:

- Where is this plot of land?
- What are the specifications of the plot of land?
- What are the official rules?
- Where are the documents that we need to turn in?
- What are the sustainability and energy efficiency standards?
- What should we include in the presentation?

Finally, the students should design a problem statement to describe their task (the problem they are solving). The problem statement will probably be something similar to the following, “We are a design team that has won a plot of land. Our task is to design an energy efficient home on the plot of land for no more than $500,000. We will present our proposal for approval of the SEEC.”

Document 2: Design Team Contract for Participation in Contest

The Design Team Contract for Participation in Contest will give the students a chance to name their design team and create a logo for it. They will also have the opportunity to discuss and assign the team roles using this document. On the contract, the design teams will need to initial to show their understanding of the three components of the task. First, they should understand that their proposal must adhere to the official rules. Next, they should initial to show an understanding of what they have to work with- a plot of land and $500,000. Finally, the students will initial the form to signify their understanding that their presentation must be made on the date due. The teacher should reinforce how important it is for the design teams to honor the contract and adhere to the due dates as they are assigned.

Figure 2: Design Team Contract for Participation in Contest

Document 3: Official Rules

Next, the design teams will receive another piece of correspondence from Gloria Higgins of SEEC listing the first three of the official rules. In order to keep the amount of new information manageable for the students, the official rules will be given over two sessions. The students will be told that the second page of the official rules was destroyed in the mail and will be arriving at a later date. Chunking the information will prevent the students from becoming overwhelmed with too much information. This document will not provide much clarity on the task, its main purpose is to help the students generate more questions and begin to think strategically about the problem. The teacher should encourage the students to ask as many questions as possible but the teacher should not answer the students' questions. This may be difficult for some teachers! A main component to problem-based learning is having the students generate and answer their own questions centered on the problem. This will help the students in the future when they are faced with problems without a clear solution. The students need opportunities to develop the critical thinking skills necessary for breaking down and tackling complex problems. In this activity, the students will follow the same process as with the previous document to analyze the Official Rules document for answers to their questions generated from the previous document and creating new questions based on the new information.

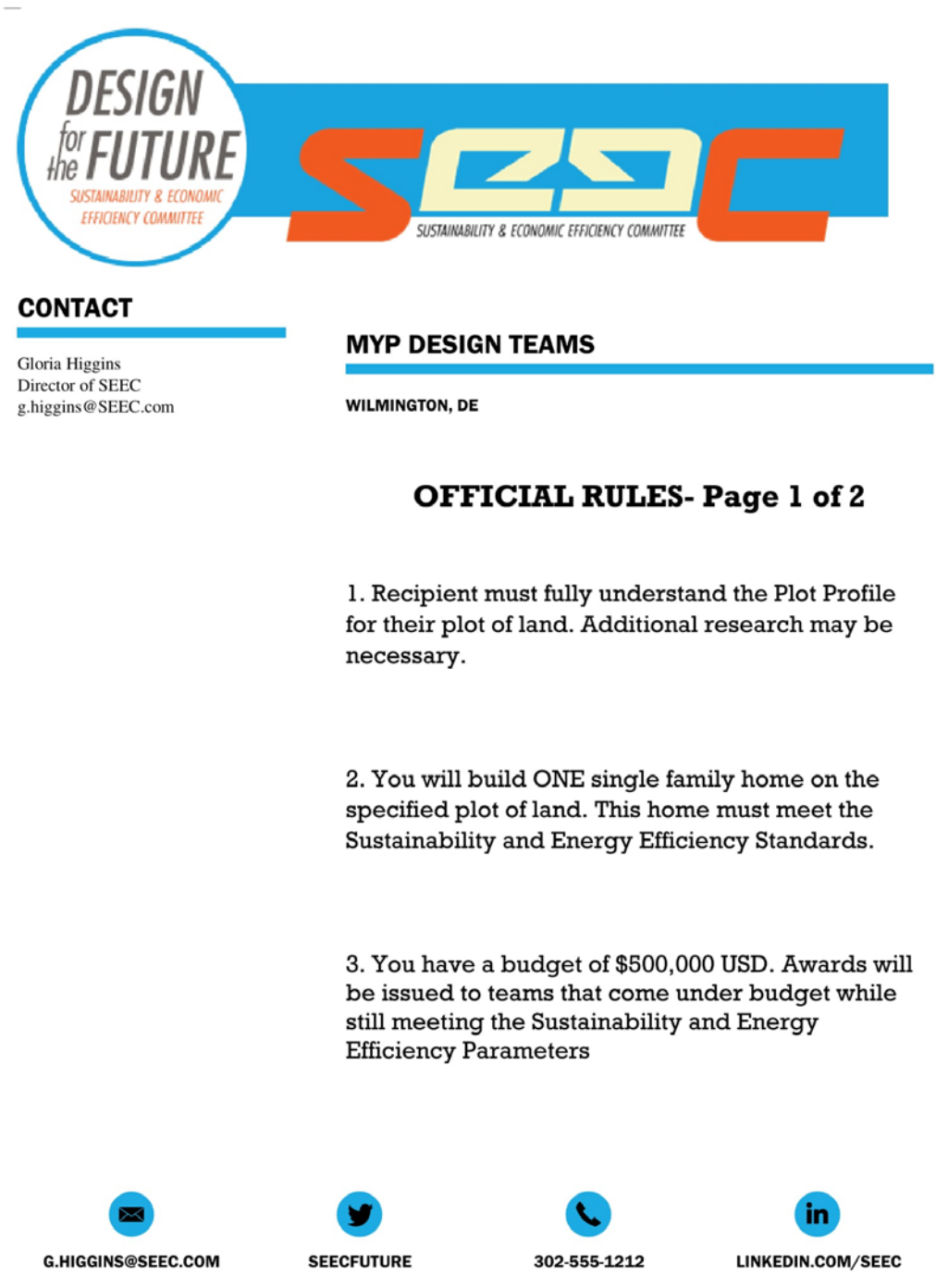

Figure 3: Official Rules, page 1

Depending on the class, the teacher could assign a student or take a student volunteer to lead students through generating the know and need to know lists and to create a problem statement. This should be done using the same process from the first document. This could be an opportunity for the students in the project manager role to show leadership. It is helpful to provide the student facilitator with a list of leading questions that can help the class if they get stuck. Possible student responses are listed below.

What we know from Page 1 of the Official Rules:

- We must understand the Plot Profile, we may need to research our land area to obtain enough information.
- We are building a single-family home that meets the Sustainability and Energy Efficiency Parameters.
- There are awards for coming under budget.

What we need to know:

- When do we receive the Land Plot Profile?
- What is a single-family home?
- What are the Sustainability and Energy Efficiency Parameters?
- How much does a house like this cost?
- What are the awards?

Finally, the students should revisit the problem statement to refine their description of the task (the problem they are solving). The problem statement will probably be similar to, "We are a design team that has won a plot of land. Our task is to design an energy efficient single-family home on a plot of land, as described on our Plot Profile, for no more than $500,000. We will present our proposal for approval of SEEC."

Activity 2: Conducting the Research and Designing a House

The second section of this unit is where the students will receive the Sustainability and Energy Efficiency Standards, conduct research, select materials, and design their home. They will receive the second page of the official rules as well as a table listing the design options, suggested materials, and websites for further information. The students should be encouraged to use the links as a means to learn basic information. They will be permitted to use other websites to obtain more information. The student playing the role of the Research Project Coordinator should be encouraged to assist team members in the research process. When students have difficulty, the teacher should encourage the students to use effective research strategies such as considering the search terms they use when looking for information and thinking about the credibility of the sources they are using. The teacher should try to use guiding questions to help the students work through their own problems instead of trying to fix the problem for them.

Land Plot Profile

The design teams will receive their Land Plot Profiles and be given time to research the site factors including the land and climate as well as the situation factors including the surrounding region, city demographics, and nearby resources. Aspen, CO and Scituate, MA were selected as sites due to their wind power potential, Los Angeles, CA and Honolulu, HI were selected due to their solar power potential, and Sonoma, CA and Washoe, NV were selected for their geothermal power potential. After receiving their Land Plot Profiles the design teams should conduct a know and need to know information session. The Project Manager should take the lead in facilitating the discussion with their design team. If the group gets stuck the teacher could step in by asking guiding questions, some examples are listed below.

Guiding Questions to Determine What the Students Know from the Land Plot Profile

- What do you now know about the location of your plot of land?
- What does the terrain look like?
- Are there any other notable characteristics about your plot of land?

Guiding Questions to Determine What the Students Need to Know from the Land Plot Profile

- What do you need to research to fully understand this plot of land?
- Is there anything on the Land Plot Profile that you don't understand?
- What additional information do you need?

Design Team	City	Link to Land Plot Real Estate Page
1	Aspen, CO	https://www.zillow.com/homedetails/Tbd-Medicine-Bow-Rd-Aspen-CO-81611/2092065416_zpid/?fullpage=true
2	Scituate, MA	https://www.zillow.com/homedetails/23-Sunset-Rd-Scituate-MA-02066/2092215063_zpid/?fullpage=true
3	Los Angeles, CA	https://www.zillow.com/homedetails/3986-S-Cloverdale-Ave-Los-Angeles-CA-90008/95587555_zpid/?fullpage=true
4	Honolulu, HI	https://www.zillow.com/homedetails/5442-Poola-St-Honolulu-HI-96821/61179975_zpid/?fullpage=true
5	Sonoma, CA	https://www.zillow.com/homedetails/518-Donald-St-Sonoma-CA-95476/96054178_zpid/?fullpage=true
6	Washoe, NV	https://www.zillow.com/homedetails/2800-Old-Ranch-Rd-Washoe-Valley-NV-89704/97531488_zpid/?fullpage=true

Page Two of the Official Rules and the Design Options Table

Page two of the official rules provides the students with an outline of the Sustainability and Energy Efficiency Standards. These standards should be used by students to help them determine which building materials to use in the construction of their single-family home. The teacher should encourage the Senior Architect and Construction Project Manager to take the lead in ensuring that this document and its values are revisited and discussed as building materials are being researched and selected. The Design Options Table provides the students with different materials that can be explored for the four categories of the home design process. The links in the table are a good starting point for students to get a basic understanding of the different elements. The students should be encouraged to research the materials further to gain a better understanding of them.

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SUSTAINABILITY & ECONOMIC EFFICIENCY COMMITTEE

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MYP DESIGN TEAMS

CONTACT

Gloria Higgins
Director of SEEC
g.higgins@SEEC.com

OFFICIAL RULES- Page 2 of 2

4. You must adhere to the Sustainability and Energy Efficiency Standards listed below.

Category 1- Building Fabric

1. using passive design- design for the climate
2. considering the home's size
3. insulating the home wisely
4. using sustainable materials and reducing waste
5. determining appropriate window placement

Category 2- Roofing

1. preservation of the environment
2. conservation of energy
3. extending the life of the roof

Category 3- Energy

1. using sources of energy that reduce greenhouse gas emissions
2. managing demand and maintain security of supplies
3. building homes that are smaller in size and highly insulated
4. investing in renewable energy for heating and cooling

Category 4- Water

1. reducing the quantity of water consumed
2. improving water quality by managing storm water and wastewater

Use the attached *Design Options* document to gain a better understanding of these standards and how you can incorporate them into your design.

Figure 4: Page 2 of Official Rules

CATEGORY 1: BUILDING FABRIC

Design Options	Websites for Research
House Orientation	https://www.smarterhomes.org.nz/smart-guides/siting-and-location/house-orientation/
Wall Types: • Dense-packed cellulose wall • Conventional wood framing • Insulated Concrete Forms • Structural Insulated Panels • The R.E.M.O.T.E wall	http://www.ecohome.net/guide/choosing-building-envelope
Reduce unnecessary spaces	http://blog.designbasics.com/great-design/5-modern-ways-to-reduce-wasted-space-in-your-floor-plan/
Ground floor for high use rooms	https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/2908/2908-9019/2908-9019_pdf.pdf
Second floor for rooms with less usage	https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/2908/2908-9019/2908-9019_pdf.pdf
Wall Insulation Materials: • Cellulose • Fiberglass • Stone wool • Straw • Polystyrene Foam • Polyisocyanurate • Cotton insulation • Thermal foil	http://www.ecohome.net/guide/choosing-right-insulation-pros-cons-applications
Window Frames • Wood • Aluminum • Vinyl • Fiberglass	http://www.ecohome.net/guide/windows-doors
Window Placement	http://www.efficientwindows.org/design.php
Number of Windows	
Window Canopies	https://energy.gov/energysaver/energy-efficient-window-treatments
Window Glaze	https://energy.gov/energysaver/energy-efficient-windows
Shading devices	http://www.yourhome.gov.au/passive-design/shading

CATEGORY 2: ROOFING

Design Options	Websites for Research
Roofing Materials: • Asphalt shingles • Metal roofs • Wooden roof • Composite roofing material • Rubber roofs • Green roofs	http://www.ecohome.net/guide/options-roofing-materials

CATEGORY 3: ENERGY

Design Options	Websites for Research
Energy Sources • Passive solar home design • Geothermal heating and cooling • Heating with electricity • Heating with natural gas • Heating with biomass fuel • Choosing, storing and burning firewood • Domestic hot water • Hydronic heating	http://www.ecohome.net/guide/heating-cooling
Wind Systems	http://www.yourhome.gov.au/energy/wind-systems
Divide home into zones	http://zonefirst.com/hvac-zoning-energy-savings/
Use sensors to turn heating and air-conditioning on and off	https://www.pge.com/en_US/business/resources/tips-trends-and-incentives/energy-insights/past-articles/ways-hvac-occupancy-sensors-can-save-money.page
Ventilation	https://energy.gov/energysaver/ventilation

CATEGORY 4: WATER

Design Options	Websites for Research
Rainwater Harvesting	http://www.yourhome.gov.au/water/rainwater https://www.smarterhomes.org.nz/smart-guides/water-and-waste/collecting-and-using-rainwater/
Outdoor Water Use • Garden Design • Soil Improvement • Lawn • Plant Selection • Mulching Watering	http://www.yourhome.gov.au/water/outdoor-water-use
Greywater	https://greywateraction.org/greywater-reuse/

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Figure 5: Design Options Table

Have the students follow the same process as with the documents from the previous activities to analyze page two of the Official Rules and the Design Options table.

What we know from page two of the Official Rules:

- We know the Energy Efficiency and Sustainability Standards.
- We will be exploring four categories of home design: building fabric, roofing, energy, and water.
- Each category has sustainability and energy efficiency standards and values.
- The Design Options Table lists different materials that can be used for each of the categories.
- There are websites to use to learn more about the design options.

What we need to know:

- What do these items look like in the real world?
- How much does it cost to put these items into place?
- Where can I get additional information?
- How should we determine which materials to use?

Finally, the students should revisit the problem statement to refine their description of the task (the problem they are solving). The problem statement will probably be similar to, "We are a design team that has won a plot of land. Our task is to research and design an energy efficient single-family home on the plot of land, as described on our Plot Profile, for no more than $500,000 using the Energy Efficiency and Sustainability Standards. We will present our proposal for approval of SEEC."

Activity 3: Communicating the Design

Letter from Gloria Higgins Regarding the Proposal Presentations

The last section of the unit is where the design teams receive the final documents from Gloria Higgins that provide them with information on the components of the Proposal Presentations. They will receive a letter from Gloria Higgins that lists the task requirements along with a contract that requires the design team to summarize the task requirements and initial to assert their understanding of the requirements. Finally, the students will receive the Scoring Rubric that will break down all parts of the project as well as the desired results.

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CONTACT

Gloria Higgins
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MYP DESIGN TEAMS

WILMINGTON, DE

RE: Proposal Presentations

Greetings!

It has come to my attention that many of the Design Teams are ready to begin planning their formal proposal presentations.

Your presentation must include the following:

1. A brief summary of the site factors including the land and climate.
2. A brief summary of the situation of your plot of land including the city demographics, city connections, and nearby resources.
3. A summary of the single-family home's design including your rational for choosing each building material or structure.
4. A list of sources in MLA format that were used to conduct your research.

Your presentation can be in whatever format you choose but it must be appropriate to the audience and purpose of this assignment. Your presentation must not exceed 10 minutes in length.

Sincerely,

Gloria Higgins
Director - SEEC

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Figure 6: Letter from Gloria Higgins of SEEC Regarding Proposal Presentations

What we know from the Proposal Presentations Letter from Gloria Higgins:

- We know what we need to include in our presentation.
- We know that we must cite our sources using MLA format.
- We know that we must stay in character.
- We only have ten minutes.
- We can format the presentation however we want.

What we need to know:

- How will our work be scored?
- Who is the audience?
- What is the purpose of our presentation?
- When will our presentations take place?

Finally, the students should revisit the problem statement to refine their description of the task (the problem they are solving). The problem statement will probably be similar to, "We are a design team that has won a plot of land. Our task is to research and design an energy efficient single-family home on the plot of land, as described on our Plot Profile, for no more than $500,000 using the Energy Efficiency and Sustainability Standards. We will present our ten-minute proposal for approval of SEEC that includes information on our land plot and climate, a description of the city demographics and nearby resources, a summary of our home design with a rational for each of the building materials we selected, and a bibliography in MLA format."

Contract for Proposal Presentations

As a checkpoint, the students will complete another contact that requires them to explain the components of the task and share their presentation ideas with the teacher. This will help the teacher to control for any potential problems the students may have with the task requirements. Next, the design teams should be given a few class periods to conduct further research and develop their presentations. The students will need to be encouraged to embrace their design team roles to ensure that all components of the task are completed. When the students are almost done, they should receive the next correspondence from SEEC. This document is the scoring rubric for the presentations.

DESIGN for the FUTURE

SEEC

CONTRACT FOR PROPOSAL PRESENTATION

Date	Design Team	Company President

Summarize the Proposal Presentation Requirements:	Team Members Initial to Indicate Understanding			
1.				
2.				
3.				
4.				

THE DESIGN TEAM AGREES TO PERFORM ALL DUTIES AS REQUESTED BY SEEC AND WILL BE SUBJECT TO THE GENERAL SUPERVISION AND ACT PERSUANT TO THE COMPANY PRESIDENT.

ALL PROPOSALS, ALONG WITH THE REQUIRED INFORMATION, MUST BE IN SEEC'S POSSESSION ON OR BEFORE THE DUE DATE TO BE CONSIDERED ELIGIBLE FOR ENTRY IN THE CONTEST.

SIGN	SIGN	SIGN	SIGN
PRINT	PRINT	PRINT	PRINT

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Figure 7: Contract for Proposal Presentations

Upon receipt of the Contract for Proposal Presentations, the design teams will be given the Scoring Rubric. The rubric divides the presentation into five components: site factors, situation factors, home design, presentation, and sources. The site and situation factors are based on the IB objective for knowing and understanding information, this standard requires the students to demonstrate their content knowledge through developed and accurate descriptions and examples. The home design component is based on the IB objective for critical thinking where the students are required to summarize information to make well-supported arguments. The presentation component is based on the IB

objective for communication. The communication standard requires the students to communicate information and ideas in a way that is completely appropriate for the audience and purpose. Finally, the sources component is also based on the IB objective for communication where the students must create a complete reference list and cite their sources. The students should be encouraged to read the document carefully and use it to double check their presentation so far. The students should be allotted a couple more class periods to refine and finish the presentations.

SCORING RUBRIC

SITE FACTORS

FACTOR	PROFICIENCY LEVEL 1-2	PROFICIENCY LEVEL 3-4	PROFICIENCY LEVEL 5-6	PROFICIENCY LEVEL 7-8
LAND	demonstrates **basic** knowledge and understanding of content and concepts through limited descriptions and/or examples.	demonstrates **satisfactory** knowledge and understanding of content and concepts through simple descriptions, explanations and examples.	demonstrates **substantial** knowledge and understanding of content and concepts through descriptions, explanations and examples.	demonstrates **detailed** knowledge and understanding of content and concepts through developed and accurate descriptions, explanations and examples.
CLIMATE	demonstrates **basic** knowledge and understanding of content and concepts through limited descriptions and/or examples.	demonstrates **satisfactory** knowledge and understanding of content and concepts through simple descriptions, explanations and examples.	demonstrates **substantial** knowledge and understanding of content and concepts through descriptions, explanations and examples.	demonstrates **detailed** knowledge and understanding of content and concepts through developed and accurate descriptions, explanations and examples.

SITUATION FACTORS

FACTOR	PROFICIENCY LEVEL 1-2	PROFICIENCY LEVEL 3-4	PROFICIENCY LEVEL 5-6	PROFICIENCY LEVEL 7-8
SURROUNDING REGION	demonstrates **basic** knowledge and understanding of content and concepts through limited descriptions and/or examples.	demonstrates **satisfactory** knowledge and understanding of content and concepts through simple descriptions, explanations and examples.	demonstrates **substantial** knowledge and understanding of content and concepts through descriptions, explanations and examples.	demonstrates **detailed** knowledge and understanding of content and concepts through developed and accurate descriptions, explanations and examples.
CITY DEMOGRAPHICS	demonstrates **basic** knowledge and understanding of content and concepts through limited descriptions and/or examples.	demonstrates **satisfactory** knowledge and understanding of content and concepts through simple descriptions, explanations and examples.	demonstrates **substantial** knowledge and understanding of content and concepts through descriptions, explanations and examples.	demonstrates **detailed** knowledge and understanding of content and concepts through developed and accurate descriptions, explanations and examples.
RESOURCES NEARBY	demonstrates **basic** knowledge and understanding of content and concepts through limited descriptions and/or examples.	demonstrates **satisfactory** knowledge and understanding of content and concepts through simple descriptions, explanations and examples.	demonstrates **substantial** knowledge and understanding of content and concepts through descriptions, explanations and examples.	demonstrates **detailed** knowledge and understanding of content and concepts through developed and accurate descriptions, explanations and examples.

HOME DESIGN

CATEGORY	PROFICIENCY LEVEL 1-2	PROFICIENCY LEVEL 3-4	PROFICIENCY LEVEL 5-6	PROFICIENCY LEVEL 7-8
CATEGORY 1: BUILDING FABRIC	begins to identify connections between information to make **simple** arguments	summarizes information to make some **adequate** arguments	summarizes information in order to make **usually valid** arguments	summarizes information to make consistent, **well-supported** arguments
CATEGORY 2: ROOFING	begins to identify connections between information to make **simple** arguments	summarizes information to make some **adequate** arguments	summarizes information in order to make **usually valid** arguments	summarizes information to make consistent, **well-supported** arguments
CATEGORY 3: ENERGY	begins to identify connections between information to make **simple** arguments	summarizes information to make some **adequate** arguments	summarizes information in order to make **usually valid** arguments	summarizes information to make consistent, **well-supported** arguments
CATEGORY 4: WATER	begins to identify connections between information to make **simple** arguments	summarizes information to make some **adequate** arguments	summarizes information in order to make **usually valid** arguments	summarizes information to make consistent, **well-supported** arguments

PRESENTATION

CATEGORY	PROFICIENCY LEVEL 1-2	PROFICIENCY LEVEL 3-4	PROFICIENCY LEVEL 5-6	PROFICIENCY LEVEL 7-8
APPROPRIATE FOR AUDIENCE AND PURPOSE	communicates information and ideas in a style that is not always clear	communicates information and ideas in a way that is somewhat clear	communicates information and ideas in a style that is mostly appropriate to the audience and purpose	communicates information and ideas in a style that is completely appropriate to the audience and purpose.

SOURCES

CATEGORY	PROFICIENCY LEVEL 1-2	PROFICIENCY LEVEL 3-4	PROFICIENCY LEVEL 5-6	PROFICIENCY LEVEL 7-8
BIBLIOGRAPHY IN MLA FORMAT	lists sources of information inconsistently.	creates an adequate reference list and sometimes cites sources.	creates an adequate reference list and usually cites sources.	creates a complete reference list and always cites sources.

TOTAL

CATEGORY	SITE FACTORS	SITUATION FACTORS	HOME DESIGN	SOURCES	PRESENTATION
SCORE	_____/16	_____/24	_____/32	_____/8	_____/8
TOTAL SCORE	_____/88	11-29 WELL BELOW STANDARD	30-49 APPROACHING THE STANDARD	50-69 MEETS THE STANDARD	70-88 EXCEEDS THE STANDARD

Figure 8: Scoring Rubric

Two Minute Interview

To gain feedback before the formal Proposal Presentations, the students will participate in five two-minute interviews. Each member of the team should focus on one component of the presentation so that the group will get feedback on all of the content of their presentation. For example, the Project Manager could focus on the site factors while the Senior Architect focuses on the situation factors and the Research Project Coordinator could focus on categories one and two of the home design component while the Construction Project Manager focuses on categories three and four of the home design. In preparation for the interviews the students should be given time to develop a two-minute mini presentation of their assigned component. They should rehearse their part to be sure that they are presenting with fluency and have fully developed their thoughts.

To begin the interviews the students should be divided into two even groups: the interviewers and the interviewees. The desks or tables should be arranged in a way where the students can meet in groups of two. The interviewees will start their two-minute mini presentation and the interviewer will take notes using the Scoring Rubric as a guide. After the two minutes, the interviewer will give feedback to the interviewee. The interviewers should be encouraged to give specific feedback related to the Scoring Rubric. Have the interviewees move to the next interviewer and continue the process four more times. Then the interviewers and interviewees should switch roles and repeat the process five more times, this will ensure that all of the students have had the opportunity to play both roles and obtain important feedback.

When the interviews are finished the design teams should regroup to discuss the feedback they received and to devise a plan for responding to what their classmates say.

Presenting to the directors of SEEC

On the date determined, the design teams will share their home design, details of the land and city, rationale for their resources selection, and bibliography. On the day of the presentations the students will be notified by the teacher that Gloria Higgins called and stated that she really wanted to be present for the presentations but unforeseen circumstances have stopped her from being able to attend. She will have to rely on the score sheets tabulated by the President. Each group will have ten minutes to present and the teacher will score the presentation using the Presentation Rubric.

Assign Awards and Reflect on the Process

All of the design teams should be commended for their hard work and dedication to developing a solution to the problem. The teacher should lead a class discussion to allow for the students to reflect on the strengths and weaknesses of their participation in this problem-based unit. Some questions that could be used are:

- How much did you know about sustainable and energy efficient homes before we started this unit?
- What problems did you encounter when you were working through this unit? How did you work through the problems you were having?
- What does your project reveal about you as a learner?
- What parts of the process were easy for you?
- What parts of the process were more difficult?
- What would you do differently in the future?

Finally, the teacher, in the role of the company president, should assign awards. The awards can take any form that the teacher deems appropriate. It could be as simple as announcing the awards and having the students stand and take a bow. The teacher could give the students award certificates or even extra credit on the assignment. Awards could be given for the following items:

- Coming under $500,000 budget
- Design team with most professional presentation
- Design team with most unique home design
- Design team with most energy efficient home design
- Most helpful design team member

Appendix 1: Standards

For this unit, the content focus is based on a Delaware Social Studies Content Standard: Geography Standard 3- 6-8b, which states, “Students will evaluate a location’s site and situation in order to identify and explain the distinctive cultural and physical characteristics, patterns of trade, and interactions that make a place unique.” Through the activities, the students will explore the site and situation of their assigned plot of land. To help the students see the uniqueness of places they will have the opportunity to hear about the other design team’s land plot and home design ideas when each team presents their final project.

The skills and processes developed in this unit are based on three of the International Baccalaureate objectives for Individuals and Societies. All of these standards will be assessed during the Proposal Presentations using the Scoring Rubric. The site and situation factors are based on the IB objective for knowing and understanding information, this standard requires the students to demonstrate their content knowledge through developed and accurate descriptions and examples. The home design component is based on the IB objective for critical thinking where the students are required to summarize information to make well-supported arguments. The presentation component is based on the IB objective for communication. The communication standard requires the students to communicate information and ideas in a way that is completely appropriate for the audience and purpose. Finally, the sources component is also based on

the IB objective for communication where the students must create a complete reference list and cite their sources.

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