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The Implementation of Project-Based Learning (PjBL) in an Earth Science Classroom: The Effectiveness of PjBL in Teaching Students about Sustainable Energy

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Abstract

The Next Generation Science Standards (NGSS) (NRC, 2013) have developed a framework for more effective pedagogical approaches in the science classroom that advance student engagement in Science, Technology, Engineering, and Math (STEM). The framework is cited in developing student understanding of three major aspects of learning: "understanding of science concepts, their identities as learner of science, and their appreciation of scientific practices and crosscutting concepts" (NGSS, 2012).The framework explains that the most effective way of transmitting these aspects of learning is through "investigation, collection and analysis of evidence, logical reasoning, and communication of information" (NGSS, 2013). Project-Based Learning (PjBL) meets these criteria, and is argued by the scientific and educational communities to be a portal for aligning science teaching to the NGSS. This project cites the wealth of support for PjBL in the science classroom. Additionally, this project proposes a unit plan that introduces PjBL in the science classroom in an attempt to engage students in genuine science learning that references the NGSS. Specifically, students work in groups throughout the unit to collaborate on research, design, data analysis, and a presentation of their understanding of the different forms and effectiveness of four types of renewable energy: solar, wind, geothermal, and hydroelectric energy. The presentation is the culmination of students' ability to collaborate in understanding the overall objectives of the unit.

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Chapter 1: Introduction

What is Project-based learning (PjBL)? Is the implementation of PjBL an appropriate approach to learning for students in the science classroom? Extensive literature suggests that PjBL is an extremely effective approach to teaching science, and, by definition, PjBL engages the students in a way that fosters genuine collaboration and learning.

Indeed, there are many definitions and executions of the functions and contexts of PjBL. Tamim and Grant (2013) define PjBL as a long-term or short-term endeavor in which students engage with each other and the content in a style that forms questions and actions to reach answers generated by the students, themselves. Teachers in a classroom that utilizes PjBL are merely facilitators of proper social interaction as well as aids in guiding students towards information that is relevant and meaningful for students in the classroom. Students must generate the questions and the product that answers the questions. Solomon (2003) further asserts that PjBL is interdisciplinary in design; therefore, the approach strengthens a student's overall academic success and confidence. It is important to note that PjBL is different from Problem-Based Learning (PBL). The *project* is used as a problem-solving approach to learning instead of telling students what it is they need to know, so it is acceptable to think of PjBL as a subcategory PBL within science teaching and learning. PjBL empowers students, it engages students in their own learning, and it forces students to ask questions and become a part of the very nature of science- inquiry.

Acknowledging the definition and the tenets of PjBL are necessary in seeing the importance of using authentic learning, such as PjBL, in the science classroom. Evidence suggests that educators have shifted from a traditional approach, which involves a predominantly teacher-student interaction towards an approach that is more engaging, enlightening, and relevant for students to develop mastery-level skills in problem-solving, communicating, goal setting, and reflection (Tamim and Grant, 2013, Lattimer and Riordan ,2011). Research spans from the general social benefits of PjBL to the scientific competency gains of the practice to the actual success that is had by students that participate in learning through engagement and project-style activities and lessons (Boss, 2003). The successes that have been observed in a classroom utilizing PjBL include cognitive gains, social gains, civic gains, and professional gains (Lawley and McEwan, 2011). In addition to the increased interest and motivation that has been witnessed in a PjBL classroom, and the cognitive abilities that are created from PjBL, there are also many studies that report increased confidence, trust, collaboration, and mastery of skills and goal setting, all qualities that are important for an individual in the *real world* (Alacapınar, 2008). Authentic learning, and specifically, PjBL provides students with many more skills, and more academic and personal success, which is why it is extremely important that science teachers consider using PjBL in the classroom.

There are caveats to PjBL; however, it has been stated that these conditions are not significant enough to hinder the benefits of PjBL. PjBL has been reported as extremely time-consuming and overwhelming to install in the classroom (Movahedzadeh, 2012). Also, PjBL may not be a technique that can be used all of the time in the classroom due to its lengthy and unique nature. Neither of these conditions are significant hindrances. Once installed, PjBL allows for genuine learning and there are other strategies that teachers can use when a PjBL approach is not an optimum choice for any given lesson, some of which will be outlined throughout this project.

Indeed, Project-based Learning (PjBL) is growing as a successful approach to teaching and learning, both in the United States and the world. In applying a PjBL approach, it is important that a teacher consider the needs of the students, and provides the students with the opportunities to grow, both in their own minds, and together as they work towards a common task. PjBL requires a major overhaul in many classrooms and school systems for it to be effective; however, the benefits of PjBL are worth the time and commitment by teachers, administrators, and students.

Significance of the Project

The purpose of PjBL is for students to "wonder, investigate, and question" through careful inquiry and project design (Lattimer and Riordan, 2011). By providing students with a PjBL format of learning, students will see growth in their cognitive skills, academic achievement skills, and other important educational and social areas. The literature cites various evidence-based strategies within PjBL that have supported the claims that PjBL is an effective type of authentic learning in which students can take control of their educational and social growth. In addition to these evidence-based strategies, PjBL enhances learning by encouraging collaboration, social etiquette, and self-reflection. "Students construct products that yield feedback and inspiration [from each other] (Spires et al, 2012). Overall, the hope behind the project that students will create in the Earth Science classroom is that genuine and effective academic growth will occur. The project is designed to teach students about sustainable energy by guiding them through a series of explorations and creations that test their abilities to challenge themselves to learn about sustainable energy.

In addition to the cognitive and academic gains that students will experience by completing the project, students will also gain competence in social and professional skills. For example, by helping each other, students can learn to work together effectively as they learn the science content as well. “Students feel a sense of increased confidence [while working together on a project]” (Mioduser and Nadav, 2008). Confidence, respect, and rapport are among many of the social skills that students will learn and develop as they work through the lesson. In regards to professionalism, students will develop skills in task-management, goal-setting, compliance, and time management (Lee et al, 2013). Finally, students are gaining the skills to communicate and meet objectives in a collaborative and respectful manner (Lawley and McEwan, 2011). All of these gains, along with the previously mentioned gains in academic achievement, are extremely beneficial in providing students with a well-rounded lesson that not only allows them to take control of their education, but grow as learners and citizens at the same time.

There are legitimate concerns and challenges cited by the literature. The first main concern in implementing PjBL for this lesson is the level of creativity that will be allowed by the teacher. In order for the teacher to make sure that students are empowered, but guided in the right direction, a delicate balance between the amount of criteria provided and the level of creativity expected must be reached. This will be addressed in the lesson plan; the objectives, as well as the standards being met, will be listed in the lesson plan, and anticipated paths of student thoughts and creations will be acknowledged as well in an attempt to mitigate this concern within PjBL. The other main concern cited throughout the literature was the ability for a teacher to accurately assess products created in a PjBL lesson. The project will acknowledge this concern, and attempt to mitigate any issues by providing a rubric or a scoring guide for each phase of the project. Phases one and three will be assessed on a point system in which students will be accountable for answering each of the prompts accurately and concisely. Phases two and four will include a rubric that addresses the criteria expected by the students, including data collection, proof of collaboration, communication skills, and a viable product. The overall significance of this project, in terms of research-based concerns, is to acknowledge the concerns, and offer feasible options for mitigating issues with the aforementioned concerns.

Finally, this project has brought light to some suggestions and thoughts going forward in order to provide teachers, schools, districts, and most importantly, students, with a well-rounded educational format. PjBL has been cited to be associated with difficulty in the amount of creativity allowed, the amount of time and effort that is necessary for scaffolding PjBL activities, the ability for a shift from teacher-focused teaching to student-focused learning, and the effectiveness of assessment in PjBL. The answer to all of these challenges is professional development. The exposure to professional development opportunities for teachers is the gateway towards a better execution of PjBL in the science classroom. Teachers may require support in building assessments and rubrics, learning scaffolding techniques, and shifting educational philosophies, all of which can be learned in a professional development setting. In addition to professional development, schools and districts must adopt beliefs and protocol that supports the implementation of newer approaches to teaching and learning in K-12 education such as project-based learning.

Overview of the Following Chapters

The following chapters of this capstone project include a review of the literature (chapter 2), a capstone project (chapter 3), cited references, and an appendix.

Chapter 2 discusses the literature related to the implementation of Project-Based Learning (PjBL) in the science classroom. The development and implementation of PjBL in a science classroom is consistently cited in the extensive literature. The main aspects that are necessary for a class to operate efficiently by using a PjBL approach, according to the literature, include professional development for teachers, concerted efforts towards collaboration and group work, engagement in metacognition and goal-setting, and activities that promote authentic, engaging investigations. Most importantly, the literature outlines a three phase approach to PjBL; in which students meet objectives relative to the curriculum as well as their own thinking in education. The initial phase is a period in which students use metacognition to learn how to learn best in a PjBL lesson.

Chapter 3 includes a project, which outlines a unit plan designed to utilize the PjBL process in a manner that will engage students in authentic and meaningful learning. In this unit plan, students, over the course of ten days, explore the concept of renewable energy. Students are required to research the various types of renewable energy to gain insight into the projects that they will conduct throughout the unit. Students will engage in collaborative and authentic learning by building models that capture various types of renewable energy, gathering and analyzing data, and presenting their findings, successes, and failures to their peers. The unit culminates with an essay and a presentation; however, students will be assessed formatively throughout the unit based on their ability to work together towards a common goal and complete the daily objectives.

The references related to the literature review and the unit plan designs are listed after chapter 3 in APA format. An appendix of materials used throughout the unit plan can be found after the references list. Specifically, the appendix has documents that are handed out to students throughout the unit, rubrics that are used to assess students throughout the unit, and explanations of activities that students complete.

Definition of Terms

Project-based learning- A teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to a complex question, problem, or challenge.

Problem-based learning- A student-centered pedagogy in which students learn about a subject through the experience of problem solving. Students learn both thinking strategies and domain knowledge

Constructivism- A perspective in education, which is based on experiential learning through real life experiences to construct and condition knowledge.

Social constructivism- A sociological theory of knowledge that applies the general philosophical constructivism into social settings, wherein groups construct knowledge for one another, collaboratively creating a small culture of shared artifacts with shared meanings.

Civic engagement- individual and collective actions designed to identify and address issues of public concern.

Performance assessment- a form of testing that requires students to perform a task rather than select an answer from a ready-made list.

Chapter 2: A Review of the Literature

Overview

What is Project-based learning (PjBL)? Is the implementation of PjBL an appropriate approach to learning for students in the science classroom? These questions will be addressed in this literature review in an attempt to rationalize PjBL as an effective format for science teaching and learning. Through careful study of general research and case studies, the review of the literature related to PjBL yields promising information regarding the success of PjBL in many different contexts. Evidence suggests that educators have shifted from an approach, which involves a predominantly teacher-student interaction towards an approach that is more engaging, enlightening, and relevant for students to develop mastery-level skills in problem-solving, communicating, goal setting, and reflection (Tamim and Grant, 2013).

The research suggests that PjBL is growing as a main form of authentic science learning in which students take control of their learning; a contrast from traditional science teaching and learning, in which students passively receive information by only their teacher. The reasons for this sustained growth is threefold; research shows real growth in “authentic learning amongst students”, growth in social and real-life competence, and growth in metacognition and reflection of successes and growths by many students (Lawley and McEwan, 2011, Chu et al., 2011). Review of the research conducted on PjBL has yielded compelling results in regards to the social and academic successes of students.

This literature review will outline the definition and tenets of PjBL; furthermore, it will provide a wealth of support in showing that PjBL is already effective in many classrooms, and has the ability to be powerful in any science classroom when used properly by all that are involved. The implications for practical application of PjBL in the science classroom will be explained as well for the reader to understand; however, the implications will be rationalized with stories of success and growth in various science classrooms. The goal of this review is to align the vast amount of literature with a practical application of PjBL in an actual science classroom.

Definition of Project-Based Learning (PjBL)

The definition of PjBL is critical for research into its effectiveness. Tamim and Grant (2013) define PjBL as a long-term or short-term endeavor in which students engage with each other and the content in a style that forms questions and actions to reach answers generated by the students, themselves. Teachers in a classroom that utilizes PjBL are merely facilitators of proper social interaction as well as aids in guiding students towards information that is relevant and meaningful for students in the classroom. Students must generate the questions and the product that answers the questions.

Solomon (2003) further asserts that PjBL is interdisciplinary in design; therefore, the approach strengthens a student's overall academic success and confidence. Solomon (2003) also explains that PjBL should not be conducted without considering the responsibility and reflection aspect of the approach. Students decide which questions and concerns to pursue, how to synthesize their newly acquired knowledge, and how to report their findings in a way that will be helpful in assessing the extent of their learning. The product of PjBL can take many forms; students can generate a model that simulates questions, a presentation that addresses concerns, a written reflection of their findings, amongst many more products. Overall, PjBL is authentic in nature; it requires students to take charge of their learning, make sense of a real-life scenario that connects to the curriculum, and analyze their understanding of the concepts (as well as provide the teacher with a formative or summative assessment of their learning).

Educational Significance of PjBL in the Science Classroom

The application of PjBL in the science classroom is far more significant than the mere definition of PjBL. There is a certain power given to students in a classroom when PjBL is approached and implemented in a proper manner.

The comprehensive study of the definition and use of PjBL, the effectiveness of the practice, and the academic and social benefits of the practice all suggests that PjBL can be used as a sustained and effective approach towards learning in many classrooms, especially the science classroom. Confidence, respect, communication, and metacognition are a few of many social gains that come with Project-based Learning. The academic gains could be even larger, as students learn how to acquire knowledge, analyze relationships, and make sense of the world around them. Definitions and facts are not necessarily useful in building knowledge, but being able to apply knowledge to a problem via a project is absolutely a piece of the foundation of authentic learning. Thus, PjBL is a major gateway for teachers to consider as a vehicle for learning and collaborating amongst students.

The relevance and applicability of the project to the *real world* carries significant weight in propelling the students towards their goals as well as the teachers' goals of the project. When students have choice in their learning, and can "construct products that yield feedback and inspiration [from each other], those products have value beyond school" (Spires et al., 2012). In addition to the real world feeling that arises from a PjBL lesson, there are critical and specific workplace skills that are learned by students as well. The students learned "investigation, design, time management, and other workplace skills" as they produced their electric cars, all of which have skills that are necessary beyond school (Solomon, 2003).

'Civic engagement' is the other monumental aspect of PjBL that is a major advantage of that style of learning in any classroom. Lawley and McEwan (2011) conducted a study on fifth-grade students, and found that by providing students with a chance to learn through inquiry in a community-wide project, those students could ready themselves for future schooling and beyond as citizens in society and integral parts of the workplace. Although fifth-grade is early on in development, Lawley and McEwan (2011) argue that it is crucial that teachers provide these students with the opportunity to learn discussion techniques, collaboration, respect, and service to each other.

Finally, in regards to application, science is about discussion and collaboration, finding meaning, exposing relationships, and communicating and sharing those findings. These tenets of science align well with the beliefs of the PjBL approach, which is why the PjBL practice is effective in the science classroom. When students engage in PjBL they begin to acknowledge a problem at hand (usually provided by the teacher), brainstorm ways to solve the problem, and work together to meet the goals of the project. This is a huge contrast from formats of teaching and learning that requires information being relayed from the teacher to the students in a setting that provides for passive learning by the students. In a classroom using PjBL, students use the scientific method without even thinking about it. Questions are provided, hypotheses are formed, tests and products are produced, and results and analysis are provided. In addition to this process, the PjBL approach supplements science with the social aspects of learning (Movahedzadeh et al., 2012). PjBL forces students to learn how to respect each other, challenge each other's thinking, and reform ideas, all of which are critical aspects of the nature of science.

Challenges of Implementing PjBL in the Classroom

It is important to acknowledge and discuss some of the challenges found in the research regarding PjBL. The main overarching theme for challenges to the PjBL approach is allowing for choice and creativity by students while maintaining appropriate content within the product (Spires et al, 2012). Thus, it is important that a teacher consider the scaffolds that must be in place within the lesson in order to guide students towards success in building and understanding their projects. This challenge also depends on the objectives of the project (Spires et al, 2012).

Another concern within PjBL is the ability to appropriately assess project-based learning. How does a teacher assess success, student growth, and understanding of the content? Boss (2012) states that the introduction of the Common Core Standards (CCS) has put more pressure on teaching and learning than ever before. Boss (2012) also claims that future assessments will begin to shift towards assessments used in PjBL already. "Rich performance tasks, that will measure students' readiness for entry-level college courses" is the ideal assessment format that schools are looking to move towards in the future (Boss, 2012). The challenge is what performance-based assessments will look like. Boss (2012) claims that formative assessments, along with rubrics and reflective formats will be necessary for providing students and educators with a comprehensive assessment of student learning.

Finally, teachers have expressed some concern in the ability to let go of some of the control and allowing for freedom and choice by students (Tamim and Grant, 2013). It is important to note that this should be the smallest of challenges within this study because it is important that teachers acknowledge the significance of allowing for that freedom. Although it may be tough for a teacher to relinquish control, it should be recognized that this can have great power over the dynamics of a classroom. Students, at all levels, can see significant success in social skills development, self-growth skills, and academic achievement when they are forced to take on the endeavor of a project on their own (Solomon, 2003).

The constructivist nature of PjBL, along with the natural engagement and hands-on approach that is utilized in PjBL, present many benefits for students in the science classroom, as well as a few challenges. It is the freedom of choice and pursuance of something of interest for students that makes PjBL a worthwhile style for teaching and learning science (Solomon, 2003). Indeed, PjBL comes with its challenges; however, this review indicates that many assertions point towards a much higher degree of success than failure in the science classroom. In review, PjBL has proven to be associated with difficulty in the amount of creativity allowed, the amount of time and effort that is necessary for scaffolding PjBL activities, the ability for a shift from teacher-focused teaching to student-focused learning, and the effectiveness of assessment in PjBL. All aspects considered, PjBL is far more powerful than traditional forms of teaching and learning in which the teacher is the 'expert' and all course material is delivered via lecture. Furthermore, the engaging and motivating nature of PjBL can lead to greater gains amongst students and schools across the country.

Overall, the challenges that cause educators to hesitate are the same reasons why educators will see extensive growth by all students. As control is shifted to the students (in a well-designed and appropriate manner) schools will see increased students motivation and engagement towards learning as a result of the use of PjBL.

Implications in Practical Use of PjBL in the Science Classroom

What is the merit in utilizing a PjBL approach? Acknowledging the challenges, but defining the successes is the idea behind most of the research found thus far. Teachers and researchers have found extensive data which reveals that students feel a sense of increased confidence (Mioduser and Nadav, 2008). Confidence is an underrated quality in education (and in many contexts in life). If students feel confident in their learning and their ability to communicate, then the amount of authentic learning that occurs grows exponentially. In a study by Mioduser and Nadav (2008), pre-tests, post-tests, and performance-tests were the modes of assessment of student confidence in their learning. Post-tests in this study revealed an impressive gain by all students (males and females as studied by Mioduser and Nadav, 2008). Both groups were above 85% mastery by the end of the project. This percentage is significant when it is considered; students felt so much confidence in their understanding that they improved in 90% of the areas tested. This study speaks to the success of PjBL as a confidence booster for students.

Collaboration is another aspect of PjBL, which is arguably, the most important tenet of PjBL. Students gain an incredible amount of skills in working together and communicating with each other in reaching a goal when they are able to work on a problem and solve it together. Again, this is a stark contrast to the traditional methods of teaching in which students passively learn science (or any subject) by recording notes from the teacher. Studies of PjBL constantly refer to the deficits of traditional teaching methods because PjBL acknowledges and satisfies the deficits that many other teaching methods possess. Students are not able to interact and communicate when they are receiving information from their teacher. However, when students are allowed to communicate with each other and correct each other, genuine learning can occur. Roessingh and Chambers (2011) explain that a student in a ‘PjBL classroom’ will gain much more than just content knowledge, but also context knowledge in learning how to effectively collaborate with other individuals. Essentially, PjBL is providing one of the single most important aspects of the 'real world' in collaboration, and this alone gives huge merit to the PjBL approach.

Self-reflection, peer reflection, and metacognition are another aspect of the PjBL approach which makes it a successful approach in the science classroom. In many studies, students provided each other with feedback on their performance. Students tend to try harder when they are being evaluated by their peers (Lattimer and Riordan, 2011). Thus, if it is known by all students that they will not only be reflecting on their learning and contributions, but they will be evaluated by their peers, then students will generally be motivated to contribute more, resulting in more learning. Lattimer and Riordan (2011) extend this point to relate it to the meaning of learning for students. The study reports that students feel like their presence in the classroom is more meaningful when they can contribute to the overall atmosphere. In addition, students report to their parents (in this study) that the overall concepts they are learning are more meaningful and relevant when they can observe and respond to other perspectives. The process of goal-setting, creating a product, and reflecting on that product and the work put into that product is a simple way for a teacher to have students doing most of the work in their learning. Metacognition is another underrated quality in a student's education. Students must be aware of how it is that they learn and communicate best; when this learning is going on in conjunction with content learning, students will see their most growth (Roessingh and Chambers, 2011). Roessingh and Chambers (2011) look at learning as "creating and recreating knowledge", which is a process based on self-growth through metacognition. Projects are an effective strategy for helping students in 'recreating knowledge'. Projects are meant to be adjusted based on new knowledge gained by trial and error. In an ideal situation, students will adapt and evolve their projects as they learn what makes sense and what does not make sense. This relates to the previously mentioned correlation between PjBL and the nature of science. If the idea of science teaching and learning is to teach children to understand the scientific process and nature, then it would be helpful for students to practice the scientific cycle of learning.

Finally, the research asserts that PjBL provides an inlet to the community for students at an early age. PjBL is explained to help students gain access to community resources as well as other various external resources. Acquiring resources and knowledge from those resources is an important skill for college and beyond, and PjBL, when conducted correctly, can provide students with the necessary skills for finding those resources (Solomon, 2003). Resources, such as online forums and websites, community organizations, local experts, and educational agencies, can all be extremely helpful in guiding a student through genuine learning.

All of aforementioned implications of PjBL in the science classroom cannot be developed correctly unless the practicality of PjBL is understood by the educators and the students in a school system. The main tenet of a successful PjBL approach is large promotion on student Self-Regulated Learning (SRL) (English and Kitsantas, 2013). English and Kitsantas (2013) have outlined a three phase approach to teaching and learning in a SRL (PjBL) classroom. The three phase approach is geared to lessen teacher direction and increase student SRL, thereby creating an environment in which all students are able to learn in a way that is motivating and effective for them. English and Kitsantas (2013) claim that the most significant practical implication of implementing the PjBL approach in any classroom is the lack of immediate receptivity by students and teachers. The roles that students would assume in a PjBL classroom conflict with the "deeply engrained habits they have developed" throughout their educational careers (English and Kitsantas, 2013). Nonetheless, the three phase approach has been supported by much literature, and is effective in practicing effective PjBL.

This section of the review will describe each phase, and how it is beneficial in theory and in practice in a science classroom. During phase 1 of PjBL, students will "launch their understanding" of the topic being covered by discussing and a developing an essential question, relative learning goals, and the objectives that should be met at the end of the topical unit (English and Kitsantas, 2013). This first phase is arguably the most important in that it takes a two-way approach to helping students develop their learning. While students are designing a way to meet the learning goals of the topical unit, all students are also activating metacognition, motivation, and prior knowledge.

In phase 2 of PjBL, students take full control of their learning through guided inquiry. Students use "iterative cycles of gathering information, making meaning, reflecting and testing findings, and revising as needed" (English and Kitsantas, 2013). This phase is where students really develop their own "path" for learning. Students should be fully engaged, at this point, in constructing their content knowledge, but also their contextual knowledge of themselves as learners. Specifically, students may be researching a problem using the internet, building a model to explain their learning, collaborating with peers to develop meaning, and presenting their ideas to peers in an attempt to further all students' understanding of the task at hand. Practically speaking, this type of Self-Regulated Learning (SRL) is the most ideal type of learning in a classroom utilizing PjBL.

The third and final phase, in this process is about reflection and evaluation for students, in which the teacher will facilitate a check for understanding and a meeting of the project goals and expectations (English and Kitsantas, 2013). "During this phase, students share their project" via presentation, discussion, or writing to show themselves and the teacher that they have met the lesson or unit objectives.

If PjBL is aligned to these three SRL phases, it is absolutely a practically sound style of learning in the science classroom. When learning becomes self-regulated and engaging, students can see genuine growth, and teachers can use their time to develop students as learners rather than simply delivering a constant flow of information via lecture.

Conclusion

Indeed, Project-based Learning (PjBL) is growing as a successful approach to teaching and learning, both in the United States and the world. Traditional forms of teaching include a teacher-centered approach where dialogue is constant from teacher *to* students. PjBL is an alternative approach, in which students collaborate with each other towards a common goal or project, and the teacher functions as a facilitator of rules, goals, and a general outcome (Lattimer and Riordan, 2011). Students constantly report excitement and structured orientation when they "create to learn" (Spire et al., 2012). Furthermore, students reflect on their own learning, and through that metacognition, understand how it is that they learn best, and how they can contribute to community-wide learning by applying their skills to a project (Movahedzadeh et al., 2012). In applying a PjBL approach, it is important that a teacher consider the needs of the students, and provides the students with the opportunities to grow, both in their own minds, and together as they work towards a common task.

The tenets of PjBL discussed throughout this literature review serve as support in the design of the unit plan project in chapter three. The modules in the capstone project in chapter are designed to utilize collaboration, engagement, and authentic learning every day so that students gain the most content knowledge as well as metacognitive knowledge during each day's lesson. The three phases discussed by English and Kitsantas (2013) have been broken down into a ten day unit, and will help the teacher and students assess their abilities and understandings constantly throughout the unit. Building, data collection and analysis, and presentations will be used daily to help students immerse themselves in collaborative and engaging learning.

Chapter 3: Project Design

Overview

This chapter contains a unit plan, with a series of modules and lessons that utilize PjBL to aid students in the understanding of the movement towards renewable and sustainable energy in the United States. This unit plan spans over ten days, and is broken into the three phases that are discussed as necessary in any PjBL lesson/unit (English and Kitsantas, 2013). Phase one aids students in learning about the objectives of the unit, necessary background information, and the thought process that each student should have as they investigate the main ideas of the unit. In this phase, students will learn to collaborate on completing the task of research and preparation for a project in which they will build physical models, collect data, and analyze the data. Phase two leads students through a series of lessons, in which students will learn about physical models that collect the various types of renewable energy. In addition, students will build their own versions of these models in an attempt to show their understanding of the content thus far. The third and final phase allows students to reflect on their understanding of renewable energy. More importantly, this phase of the unit allows students to grow together as they collaborate to present their understanding, as well as their ability to learn together, to their peers. The three phases culminate to deliver a presentation, along with other documents, that displays student collaboration and genuine, authentic learning by all students.

Rationale for Project Development

As previously mentioned, this unit has adopted the three-phase approach to teaching and learning via PjBL, discussed by English and Kitsantas (2013). This approach was chosen because of the vast amount of evidence and literature that shows authentic Self-Regulated learning (SRL) by all students in the classroom. This PjBL unit pushes students to work together, learn the content for themselves, and be held accountable to each other and to the teacher. This notion is extremely powerful because students are not able to sit passively through class in a unit fueled by PjBL. In a science classroom, it is already important to inquire, investigate, analyze and communicate the information that is being learned; furthermore, PjBL is an exceptionally efficient style of teaching and learning that naturally forces inquiry, investigation, analysis, and communication of ideas. Specifically, students will inquire about four types of renewable energy, regions of the United States, which would benefit from the implementation of these types of renewable energy; furthermore, students will collect their own data regarding the types of renewable energy and communicate their findings and successes with their peers. This is a powerful style of learning because students will be held to a high standard by each other, as well as the teacher in the classroom.

I chose this topic for my curriculum project because of its growing relevance in the real world, as well as its growing presence in the Earth Science curriculum. The spread of Science, Technology, Engineering, and Math (STEM) and the relationship between all of the aspects of STEM has cause a surge in topics such as energy, and specifically, renewable energy. The understanding of renewable energy gives students an edge in the real world; students will gain knowledge about the future of energy, as well as have a competitive edge if they choose to pursue further education and vocation in the field of renewable energy. The Earth Science curriculum traditionally puts little emphasis on energy; however, the growth of the Next Generation Science Standards (NGSS), and its relationship with STEM, has started to change the course curriculum, and this unit is a proactive step towards meeting the NGSS in a high school Earth Science classroom.

Earth Science Unit Plan Outline- Renewable Energy- Which is the Best?

Unit title:	Resources, Renewable and Nonrenewable
Unit format:	Project-Based Learning- Students will research, *create to learn* and present their project and findings. This project should be mostly student-oriented, and the teacher is merely a facilitator of the project. The teacher should ensure that students are meeting the criteria by using daily check ins; however, the research, building, and presentation should all be designed by the students.
Course:	High School Earth Science
NYS Standard:	NYS standard 1, key idea 2- "Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity." NYS Standard 7, Key Idea 2- Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.
Summary:	There are three main phases to the project. The project will involve students working together to discover the most efficient types of sustainable energy that can be harvested in their community. Each group in the class will be assigned to a distinct location in the United States, in which they will research, experiment and conclude which renewable energy would be best suitable for that area of the country. *Phase one*- students will be required to research the types of sustainable energy, which would be beneficial to the local area, and the costs and logistics of harvesting that sustainable energy. Students will research each of the following types of renewable energy: hydropower, solar power, wind power, and geothermal power. Lesson 1- Students will identify the objectives of the unit, so that they understand where they should be as a group at the end of the ten days. Students will research solar and wind energy as means for collecting and utilizing renewable energy. Students will attempt to identify a specific region of the United States, and rationalize why either of these two types of energy would be most efficient in that particular region of the U.S. Lesson 2- Students will further their understanding of the objectives, and begin research on two more types of renewable energy- geothermal and hydroelectric energy. Lesson 3- Students will finalize their research with a culminating activity which requires them to write about their findings,

	discuss their findings with each other and another group. In addition to the presentation aspect of PjBL, students will self-regulate their learning and their peers' learning by reflecting on their collaboration and metacognition thus far in the unit. *Phase two*- students will be required to design a simple prototype for collecting the energy for each of the four types of renewable energy listed above. For example, students may start with wind energy as a form of sustainable energy to test; the next step will be for students to design a (very simple) anemometer and a windmill that effectively measures and collects local winds. Lesson 4- This is the first day of model designing, and students will choose to design a model that collects either solar energy or wind energy. Students will collaborate to learn the design, and recreate the physical model. Groups should assign roles to each member to practice collaboration towards a common task. Lesson 5- This is the second day for students to build their physical models. Students will either finish their models from the previous lesson or begin to build their model for either geothermal or hydroelectric energy. Students should assign or continue to use the roles assigned to members from the previous lesson. Students should spend time at the end of the last three lessons assessing each other's contribution to the group. Lesson 6- This lesson begins the second part of phase two. Students will begin to troubleshoot their models, ensure that their models represent the prototypes that have seen from the teacher, and collect data. Data collection will be recorded and eventually analyzed and communicated to peers. Lesson 7- Students have likely recorded data from one of their models at this point and organized their data into the provided charts. Students should move on to their other model if they are ready or finish data collection from their first model. This is a continuation of collaboration towards data collection and organization. Lesson 8- This is the final lesson within phase two. Students should finish their data collection and organization. Assessment by the teacher has been executed throughout; however, teacher input and assessment should be heavy at this point; in addition, students are evaluating their peers on their contribution in this phase of the unit. *Phase three*- Students will be required to present their project to the class. The presentation will include their research on the sustainable energy that they chose to harvest, the cost for collecting that type of energy, and the data collected by running their equipment outside. Lesson 9- This lesson is the beginning of the communication and evaluation phase. Students will reflect on their project, and prepare a presentation of their research and reflection to share with their peers. This is the culminating piece of PjBL, and the most important for the students.

	Students should learn a tremendous amount about themselves, and their group, and be ready to share that information with the class. Lesson 10- In this lesson, students will share a brief presentation with the class to show that they have properly reflected on their work over the last ten days. Students should explain the research they found, the conclusions that they have made, and how they worked together well, as well as how they could improve on their individual and group learning skills.
Rationale aligned with science standards:	This unit is intended to align with the new *Next Generation Science (NGSS).* Specifically, the PjBL approach should align with the 'performance' aspect of NGSS. "Further, students should develop an understanding of the enterprise of science as a whole—the wondering, investigating, questioning, data collecting and analyzing" (NGSS). The purpose of PjBL is for students to "wonder, investigate, and question" through careful inquiry and project design. In addition to these evidence-based strategies, PjBL enhances learning by encouraging collaboration, social etiquette, and self-reflection.
Possible Misconceptions:	The project is a simplified approach towards understanding the science and engineering associated with harvesting sustainable energy. Students will need to research actual examples of sustainable energy harvesting in order to understand the most effective and efficient ways to harvest energy. Anticipated misconceptions include: -Understanding of the term *renewable*, use and efficiency of particular types of renewable energy -Renewable energy is always cheaper than non-renewable energy sources -Renewable energy sources never produce any pollution when we use them -Renewable energy sources always involve energy sources whose availability is unlimited -Renewable Energy is unaffordable -It's not a realistic choice for developing countries -The general public has no say in the movement towards renewable energy In an attempt to mitigate the anticipated misconceptions of students, this unit has students conduct research into the types of renewable energy, where we find them in the U.S., and how they are collected. While students are building a physical model that "collects" a certain type of renewable energy, this is a simplified model, and that must be made clear to students. In an attempt to provide students with a visual representation of actual instruments that collect renewable energy, the teacher will guide students towards visuals in their research, and in addition to the research, the teacher will show students actual models of complete and elaborate instruments. Students must also know what it means to be a renewable resource. Students will state that "it is not always windy" or "the Sun will run out"; it

	will be important for the teacher to teach students that a renewable resource is something that can be replaced naturally *in our lifetime*, and before humans can deplete that resource. By this definition, the four types of renewable energy that we are studying in this unit, solar, wind, geothermal, and hydroelectric energy, can be considered renewable. There are also anticipated misconceptions of students related to the classroom management plan during PjBL: -An understanding of the term *collaboration.* -Student understanding of authentic "work" versus traditional paper and pencil "work". The idea of collaboration is integral to any PjBL activity or unit. Students must have a good understanding of the term collaboration. Therefore, the teacher must partake in teaching students what collaboration is, and what collaboration looks like in the initial phase of the unit. Students will reflect daily on their ability to collaborate, and this will serve as an assessment of how well students understand the idea of collaboration. Collaboration means that "an individual works with one or many other people to create or produce something". This is the very idea of the entire unit. Students will produce models, create documents, and present findings, all while working together. At the end of the unit, students will be asked to reflect on how well they were able to collaborate, and this should mitigate any confusion or misconceptions as to how students should work together to achieve the objectives of the unit. This style of teaching and learning will be much more meaningful for students than a traditional style of teaching and learning because it will become very obvious to the teacher and students if anyone does not understand the major concepts of the unit. If students are learning passively, then the teacher is not able to constantly and formatively check in on student understanding; in this unit, the teacher is constantly assessing the students, and the students are actively displaying their conceptions and misconceptions.
Supplemental Artifacts:	Students will complete a series of documents that display their participation in each lesson. In addition, students will display their ability to collaborate and meet the goals of each lesson, and the unit as a whole. Documents that are attached include: - Data tables for each type of renewable energy. -Student reflection and evaluation worksheets. - Criteria for essays/ letters to students in the class. -Vocabulary search worksheets. -Computer with internet access- Students will be taught the process and significance of ethical internet research. - Building kits for students to produce models that represent and capture a

	specific type of renewable energy.
Suggestions:	This PjBL unit should be done over the course of ten 40-minute class periods. It is recommended that students have at least two periods for research and worksheet completion, three periods for design and construction of their project, three periods for data collection, one period for analysis and presentation preparation, and one period to present their research, project, and data to the class. There are opportunities for further enrichment of student knowledge and collaboration in each lesson throughout the unit. Students that finish early during any activity are expected to continue their work by meeting the "*further enrichment"* objective of the lesson. Students that struggle to meet the daily objectives should be paired with students whom are excelling at understanding the material. The teacher should provide guidance to students throughout each lesson in order to ensure that collaboration is constantly occurring to foster student learning.
Accommodations/ Modifications for students	This unit requires students to actively engage with the teacher and their peers. Some students may be hesitant to engage due to personal matters, IEP, 504, or alternative education plans. In this case, students should consider these alternatives: If outcome of any particular lesson is not what is expected, students should work as a group to consider what their findings mean for renewable energy as a feasible option. This can be a separate discussion forum in class. Students can also communicate their discrepancies on the class website/ blog. Students who choose not to work with their peers can conduct research, and communicate their findings via an internet blog, poster, etc. Students with IEP/ 504 accommodations may need: -Extra time -Less workload -Less interaction -More guidance These accommodations can be met by providing a scaled down version of the project packet. Students can choose to spend their time on either the research phases, the building phases, or the presentation phases, based on their comfort level and skillset.

A template and explanation of each section of a lesson plan for the unit:

Day: *This is the day out of the ten day unit.*

Rationale: *This section is an explanation of the lesson and why the lesson is important for students to meet the objectives, learn the content, and meet the context of Project-Based Learning (PjBL).*

Materials needed: *This is a description of the materials needed for the students to complete the tasks of the lesson. Materials include any physical materials, worksheets, and evaluation.*

Objectives: *This section describes the objectives that the teacher will provide the students with at the beginning of each lesson. The "further enrichment objective in italics is for high achieving students that complete the standard objectives of each day.*

Lesson Plan: *This section will be displayed in table format. The table will break the lesson into subtitles; explain the students' actions, and the teacher's actions throughout the lesson.* ***Necessary documents will be placed directly behind lesson plan and in the appendix.***

Lesson section	Teacher actions	Student actions
Anticipatory set *This section introduces the lesson and accompanying activities for the day.*	*The teacher is scaffolding the activities while*	*The students are engaging in some introductory activity.*
Activating Learning Strategy *This section is for students to become familiar with lesson objectives and begin activities.*	The teacher is explaining objectives, monitoring student progress, and evaluating group work.	The students are engaging in an initial phase of Project-Based Learning (PjBL).
Cognitive Learning Strategy *In this section, students collaborate to meet goals and build projects.*	The teacher is facilitating group collaboration, evaluating project progress, and modeling work for the students.	The students are fully engaged in a collaborative activity related to PjBL.
Summarizing Activity *In this section, students analyze and reflect on their collaboration.*	The teacher is collecting student feedback, and reflecting on points to address for the next lesson.	The students are reflecting on their daily work and evaluating their peers in regards to collaboration and project progress.

Day 1 Lesson Plan- What are *renewable resources?*

Rationale:

This lesson provides students with an introduction to the unit, in which students will learn the process, and the importance, of research and information gathering. Groups will be made at this point, in which students of all abilities will be mixed. Ideally, groups will have three students, a mix of students with all different abilities in Earth Science class. This lesson is important because students learn the foundation for the unit. Students also learn what *collaboration* means, and how to properly use collaboration to grow in their learning. The goal of this lesson is to orient students towards successful group learning, setting goals, and meeting those goals as a group. Discussion and communication, both verbal and nonverbal, will reinforce learning for each student.

Materials needed:

-Project packet (attached)
-Computer with internet access
  -ScienceDictionary.org (Students must be taught how to properly research vocabulary terms and information as well as how to properly cite the research).
-Microsoft Word
-Peer evaluation sheets (attached)

Objectives:

-Students will be able to define at least two vocabulary words from the lesson to another student.
-Students will identify the components and needs of a Project-Based Lesson.
-Students will write a letter to a student in the class about their research.
-*Further enrichment- Students will design another format for communicating their learning.*

Lesson Plan:

Pre-unit activity- The teacher will explain the unit, distribute the packet, and discuss with students their roles during a Project-Based Learning activity:

Lesson section (subtitle)	Teacher actions	Student actions
Engagement activity *This beginning section is meant to engage students in the content and with each*	The teacher should begin with a class discussion: -What do you already know about renewable energy? What about nonrenewable	Students should take a couple minutes to gather their thoughts. Students will then engage in a

other in the learning process	energy? -Where have you seen renewable energy collection in your life? -Which type of renewable energy would be efficient in New York? Why?	class discussion with each other as the teacher facilitates discussion.
Anticipatory set *Vocabulary search*	The teacher will model techniques for researching vocabulary terms. In addition, the teacher is circulating the room, monitoring student research and collaboration. Teacher questions include: What is (renewable energy)? Where do we see this energy harvested in the U.S.? How has your group worked together during this phase? Teacher assessment: Are students working together? Are students on task? Are students writing their understanding? Are students sharing their understanding?	Students will look up the vocabulary words on page six of the project packet relating to solar and wind power. Students will fill in the definitions in the space provided. Partners should compare their findings for vocabulary to check for accuracy. *See **Appendix**, page 62*
Activating Learning Strategy *Group research activity*	The teacher should check for understanding by making sure students are answering the prompts on the worksheet. The worksheet will be handed in at the end of day 3. Teacher assessment: Collection of vocabulary	Students will research the process of harvesting energy via solar and wind power. *Students will answer the prompts given under "Part 1-The Research Project", in **Appendix**, page 64*

	sheets for review Have students met first two objectives at this point?	
Cognitive Learning Strategy *Group writing and discussion activity*	The teacher will provide students with a sheet that provides prompts for each section of the essay. The essay should have an introduction, evidence and discussion of the renewable energy, and a conclusion.	Students will write a short essay to a classmate, answering the prompts given in their project packet, *following the criteria listed under "Part 1- The Research project", in **Appendix**, page 64* If extra time permits, students should conduct a Think-Pair-Share of their collaborative work.
Summarizing activity *Group presentation*	The teacher will circulate the room to listen to the discussion amongst students. The teacher will assess student productivity based on peer evaluation worksheets. Teacher questions: What have you learned so far? What have you learned from the other group so far? How can you use this information to further your learning through your project?	Students will share one or two main findings with another group in the class. This is a mini, informal presentation format. *See "Mini presentation" worksheet in project packet, **Appendix**, page 72*

Day 1

Vocabulary set 1:

Solar power-

Solar panel-

Kilowatt-

Photovoltaic cell-

Vocabulary set 2:

Wind power-

Anemometer-

Windmill-

Part 1- The Research Project Lesson #3

Directions: Choose an area of the United States; this should be a State such as New York State. Check with me to make sure you have picked an area different than any other group. Research the various sources of renewable energy that are already used by the State. Your research should include analyses of the effectiveness of the various renewable energy sources in the State. You should consider:

- Which State did you pick?
- What type of renewable energy is already present in the State?
- Which type of renewable energy *could* be used in the State based on your knowledge of Earth Science?
- Why would the type of renewable energy you choose be effective?
- What are the benefits of your choice?
- What are the drawbacks of your choice?

Your report must be:

- 12 point font
- Times New Roman
- Double spaced
- 1-2 full pages

Once you have decided on a type of renewable energy, you must see your teacher for the criteria that you must try to meet with your model that you will build. For example, if you choose to produce a model that will capture solar energy, the criteria that may have to be met is that you must build a device that can reach 200 degrees Fahrenheit, using only solar rays.

Name:__________________________________ Date:_______________
Earth Science Mini presentation prep

Directions: Answer the following prompts below in preparation to share your research with another group.

What type of renewable energy is your group researching?

Share one interesting fact you learned that you did not know about that renewable energy:

After listening to the other group's mini presentation, answer the following prompts below:

What type of renewable energy is the other group researching?

Share one interesting fact you learned from the other group:

Did the other group do a satisfactory job of researching and explaining? Why or why not?

Day 2 Lesson Plan- How do we harvest renewable energy?

Rationale:

This lesson is the second day of research and information gathering for students. Students will research the other renewable resources, geothermal and hydroelectric energy. The significance of this research is so that students can connect the content of the unit to the projects they will build later in the unit. This is a continuation of phase 1 of PjBL (English and Kitsantas, 2013). This lesson is important for students to not only develop their learning through research, but begin to share their information, and work together to meet the lesson and unit objectives. Students will be accountable for learning the content on their own. The teacher is merely a facilitator of group work and solid collaboration. Students will be assessed throughout the lesson on their ability to exhibit on task behavior, in groups, and reflect on their meeting of the objectives.

Materials needed:

-Project packet (attached)
-Computer with internet access
    -ScienceDictionary.org (Students must be taught how to properly research vocabulary terms and information as well as how to properly cite the research).
-Microsoft Word
-Peer evaluation sheets (attached)

Objectives:

- Students will be able to define at least two vocabulary words from the lesson to another student.
-Students will write a letter to a student in the class about their day's research.
-Students will be able to work together to display their learning and research.
-*Further enrichment- Students will design another format for communicating their learning.*

Lesson Plan:

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set *Vocabulary search*	The teacher will model techniques for researching vocabulary terms. In addition, the teacher is circulating the room, monitoring student research and collaboration. Teacher questions include:	Students will look up the vocabulary words on the first page of the project packet relating to hydroelectric and geothermal power. Fill in the definitions in the space provided.

	What is (renewable energy)? Where do we see this energy harvested in the U.S.? How has your group worked together during this phase? Teacher assessment: Are students working together? Are students on task? Are students writing their understanding? Are students sharing their understanding?	*See **Appendix**, page 63*
Activating Learning Strategy	The teacher should check for understanding by making sure students are answering the prompts on the worksheet. Teacher assessment: Collection of vocabulary sheets for review Have students met first two objectives at this point?	Students will research the process of harvesting energy via hydroelectric and geothermal power. *Students will answer the prompts given under "Part 1- The Research Project", in **Appendix,** page 64*
Cognitive Learning Strategy	The teacher will provide students with a sheet that provides prompts for each section of the essay. The essay should have an introduction, evidence and discussion of the renewable energy, and a conclusion.	Students will write another short essay to a classmate, answering the prompts given in their project packet, *following the criteria listed under "Part 1- The Research project", in **Appendix,** page 64* If extra time permits, students should conduct a Think-Pair-Share of their collaborative work.
Summarizing activity	The teacher will circulate the room to listen to the discussion amongst students. The teacher will assess student	Students will share one or two main findings with another group in the class. This is a mini, informal presentation

	productivity based on peer evaluation worksheets. Teacher questions: What have you learned so far? What have you learned from the other group so far? How can you use this information to further your learning through your project?	format. *See "Mini presentation" worksheet in project packet,* ***Appendix****, page 72*

Day 2 Lesson #2

Vocabulary set 3:

Geothermal power-

Thermal vents-

Earth's mantle-

Vocabulary set 4:

Hydroelectric power-

Water wheel-

Discharge-

Water cycle-

Part 1- The Research Project Lesson #3

Directions: Choose an area of the United States, this should be a State such as New York State. Check with me to make sure you have picked an area different than any other group. Research the various sources of renewable energy that are already used by the State. Your research should include analyses of the effectiveness of the various renewable energy sources in the State. You should consider:

- Which State did you pick?
- What type of renewable energy is already present in the State?
- Which type of renewable energy *could* be used in the State based on your knowledge of Earth Science?
- Why would the type of renewable energy you choose be effective?
- What are the benefits of your choice?
- What are the drawbacks of your choice?

Your report must be:

- 12 point font
- Times New Roman
- Double spaced
- 1-2 full pages

Once you have decided on a type of renewable energy, you must see your teacher for the criteria that you must try to meet with your model that you will build. For example, if you choose to produce a model that will capture solar energy, the criteria that may have to be met is that you must build a device that can reach 200 degrees Fahrenheit, using only solar rays.

Name:__________________________________ Date:_______________
Earth Science Mini presentation prep

Directions: Answer the following prompts below in preparation to share your research with another group.

What type of renewable energy is your group researching?

Share one interesting fact you learned that you did not know about that renewable energy:

After listening to the other group's mini presentation, answer the following prompts below:

What type of renewable energy is the other group researching?

Share one interesting fact you learned from the other group:

Did the other group do a satisfactory job of researching and explaining? Why or why not?

Day 3 Lesson Plan- Where do we see renewable energy in the U.S.?

Rationale:

This lesson is the final phase of phase 1 in PjBL (English and Kitsantas, 2013). Students will finalize their understanding of research analysis and information synthesis. Students will finalize their research documents, their writing components, and their evaluation of each other in regards to their understanding of renewable energy as well as the importance of research and collaboration within this unit. This lesson is crucial for students to communicate their findings and their reflection on their individual learning and group learning. The teacher will facilitate a class discussion at the end of class so not only assess student learning, but help students use communication as their main style of learning. Students must be active in their learning rather than passively absorbing information.

Materials needed:

-Project packet (attached)
-Computer with internet access
  -ScienceDictionary.org (Students must be taught how to properly research vocabulary terms and information as well as how to properly cite the research).
-Microsoft Word
-Peer evaluation sheets (attached)

Objectives:

-- Students will be able to define at least two vocabulary words from the lesson to another student.
-Students will write a letter to a student in the class about their day's research.
-Students will assess their partners' contribution to the project thus far by completing a worksheet.
-Further enrichment- Students will work together to identify one other type of renewable resource that has not been assigned.

Lesson Plan:

This is an extended work day for students to develop their research and their writing/ findings about the various types of renewable energy.

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set *Vocabulary search*	The teacher will model techniques for researching vocabulary terms. In addition,	Students will finish any vocabulary searches for any words related to each of the

	the teacher is circulating the room, monitoring student research and collaboration. Teacher questions include: What is (renewable energy)? Where do we see this energy harvested in the U.S.? How has your group worked together during this phase? Teacher assessment: Are students working together? Are students on task? Are students writing their understanding? Are students sharing their understanding?	four types of renewable energy. *See* ***Appendix****, pages 62 and 63*
Activating Learning Strategy	The teacher should check for understanding by making sure students are answering the prompts on the worksheet. Teacher assessment: Collection of vocabulary sheets for review Have students met first two objectives at this point?	Students will finish all research of renewable energy sources, and ensure that they have cited the information they have gathered. *Students will answer the prompts given under "Part 1- The Research Project", in* ***Appendix,*** *page 64*
Cognitive Learning Strategy	The teacher will provide students with a sheet that provides prompts for each section of the essay. The essay should have an introduction, evidence and discussion of the renewable energy, and a conclusion.	Students compare their research from different sources. Using the work sheet attached, students will check if they have covered the criteria for their project research. *See page 26 in the project packet* If extra time permits, students

		should conduct a Think-Pair-Share of their collaborative work.
Summarizing activity	The teacher will circulate the room to listen to the discussion amongst students. The teacher will assess student productivity based on peer evaluation worksheets. Teacher questions: What have you learned so far? What have you learned from the other group so far? How can you use this information to further your learning through your project?	Students will share one or two main findings with another group in the class. This is a mini, informal presentation format. *See "Mini presentation" worksheet in project packet,* ***Appendix****, page 72*

Name:_________________________________ Date:_______________
Earth Science Mini presentation prep

Directions: Answer the following prompts below in preparation to share your research with another group.

What type of renewable energy is your group researching?

Share one interesting fact you learned that you did not know about that renewable energy:

After listening to the other group's mini presentation, answer the following prompts below:

What type of renewable energy is the other group researching?

Share one interesting fact you learned from the other group:

Did the other group do a satisfactory job of researching and explaining? Why or why not?

Day 4 Lesson Plan- How do we collect solar and wind energy?

Rationale:

This day begins phase 2 of the PjBL process (English and Kitsantas, 2013). Students will use their knowledge of the four renewable resources to analyze and build models for collection of the renewable energies. Students will receive a procedure for building models, along with data collection sheets, to learn how to collaborate towards the common task of data analysis and scientific discussion. These components are key aspects of the scientific method. Students should connect their learning of the research and the actual project design to real-world applications of renewable energy. Students should communicate the importance of renewable energy in their homes, in businesses, transportation, etc. This phase begins the visual, interpersonal, and hands-on aspects of science learning. Students that have struggled to understand the content up to this point should begin to develop a better understanding via visual learning.

Materials needed:

-Pizza box/ cardboard box
-Aluminum foil
-Scissors
-Duct tape
-*Frey Scientific* Anemometer kit with instructions
Data sheets (attached)
-Peer evaluation sheets (attached)

Objectives:

-Students will build a simple mechanism that can measure and/or collect solar and wind energy.
-Students will analyze the parts necessary for solar and wind energy collection.
-*Further enrichment: Students will design a template that displays and labels the necessary parts for their model. This will be students' own interpretation of the instructions that came with the kit.*

Lesson Plan:

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set	The teacher will display the model for the day's activities, which are a solar oven and a wind anemometer. The teacher will show students the materials needed, and the	Students will look at the provided prototypes for a solar oven and an anemometer and write in the materials needed and the quantity to build their own product in the provided

	proper technique in gathering data. The data sheets and analysis from the project packet should be referenced by the teacher.	worksheet. *See "supply list" sheet in the project packet,* ***Appendix,*** *page 75*
Activating Learning Strategy	The teacher will check that students have the proper materials. The assignment of jobs for each student should also be closely monitored. Teacher assessment: Is the supply list accurate? This is a check for understanding	Students will follow the instructions provided in the energy kits and assign each member of the group a job (in addition to building) during the project. The jobs will be: designer, timekeeper and data collector, and 'manager' (the manager will help build and make sure the model resembles the prototype/ kit model.
Cognitive Learning Strategy	The teacher should fill out an assessment of student productivity and collaboration for the lesson's activities. This will be considered in the overall grade for the student. Teacher assessment: Have students assigned jobs? Are students working together? Are students communicating their ideas?	Students will build their own version of a wind anemometer and a solar oven. *See kit instructions for solar and wind energy*
Summarizing activity	He teacher will reference the objectives, and check for understanding by the students by checking models, assessing understanding, and monitoring peer evaluation.	Students will fill out the Ticket Out The Door (TOTD) slip. Each member of the team is required to fill out a slip. *See "Peer evaluation slip" in the Project Packet,* ***Appendix,***

	Class discussion should be encouraged by the teacher with rephrasing, extension of student feedback, and further reflection of student input.	*page 77* Students should spend the last couple minutes of class discussing what successes and failures they had during project design.

Name:___________________________________ Date:_______________

Earth Science Lesson #4, 5, 6

Supply List

Directions: Fill in the blanks below as part of your analysis of the equipment needed to collect renewable energy.

Your partner(s): ______________________________________

____

Renewable energy you are studying: ____

Supplies needed	**Quantity**

Name:____ Date:____________________

Earth Science- Mr. Johnson Peer evaluation

Directions: Answer the prompts below <u>for each partner.</u> Using the scale, circle 1 through 5, to rate your partners.

Partner 1 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Partner 2 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Day 5 Lesson Plan- How do we collect geothermal and hydroelectric energy?

Rationale:

In this lesson, students will continue their efforts to build models, collect data, analyze the data, and discuss the significance of the data related to solar energy. Students will rationalize which region of the U.S. is suitable for their model to collect solar energy. This is a continuation of phase 2, as explained by English and Kitsantas (2013). Students will reflect and collaborate on the aspects of the scientific method that they have developed within this lesson.

Materials needed:

-*Frey Scientific* Water wheel
-Sink/ water supply
-Timer
-*Monster Marketplace* Geothermal energy kit
-Data sheets (attached)
-Peer evaluation sheets (attached)

Objectives:

-Students will build a simple mechanism that can measure and/or collect hydroelectric and geothermal energy.
-Students will analyze and record the parts necessary for hydroelectric and geothermal energy collection.
-*Further enrichment: Students will design a template that displays and labels the necessary parts for their model. This will be students' own interpretation of the instructions that came with the kit.*

Lesson Plan:

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set	The teacher will display the model for the day's activities, which are a water wheel (hydropower) and geothermal collection by heat conduction. The teacher will show students the materials needed, and the proper technique in gathering data. The data sheets and analysis from the project	Students will look at the provided prototypes for a hydroelectric wheel and a simulated heat generator collector, and write in the materials needed and the quantity to build their own product in the provided worksheet.

	packet should be referenced by the teacher.	*See "supply list" sheet in the project packet,* ***Appendix,*** *page 75*
Activating Learning Strategy	The teacher will check that students have the proper materials. The assignment of jobs for each student should also be closely monitored.	Students will follow the instructions provided in the energy kits and assign each member of the group a job during the project. The jobs will be: designer, timekeeper and data collector, and 'manager' (the manager will help build and make sure the model resembles the prototype/ kit model.
Cognitive Learning Strategy	The teacher should fill out an assessment of student productivity and collaboration for the lesson's activities. This will be considered in the overall grade for the student.	Students will build their own version of a hydroelectric wheel and a simulated heat collector. *See kit instructions for hydroelectric and geothermal energy*
Summarizing activity	The teacher will reference the objectives, and check for understanding by the students by checking models, assessing understanding, and monitoring peer evaluation. Class discussion should be encouraged by the teacher with rephrasing, extension of student feedback, and further reflection of student input.	Students will fill out the Ticket Out The Door (TOTD) slip. Each member of the team is required to fill out a slip. *See "Peer evaluation slip" in the Project Packet,* ***Appendix,*** *page 77* Students should spend the last couple minutes of class discussing what successes and failures they had during project design.

Name:___________________________________ Date:_______________

Earth Science Lesson #4, 5, 6

Supply List

Directions: Fill in the blanks below as part of your analysis of the equipment needed to collect renewable energy.

Your partner(s): ______________________________________

____

Renewable energy you are studying: ____

Supplies needed	**Quantity**

Name:______________________________________ Date:___________________

Earth Science- Mr. Johnson Peer evaluation

Directions: Answer the prompts below <u>for each partner.</u> Using the scale, circle 1 through 5, to rate your partners.

Partner 1 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Partner 2 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Day 6 Lesson Plan- How does the technology run to collect renewable energy?

Rationale:

In this lesson, students will work with each other, and the teacher, to develop their data analysis. The students will monitor their success in developing sufficient models, and assess their ability to measure the collection of renewable energy, and the possibility for the types of renewable win energy to be used within a particular region of the U.S.

Materials needed:

-Completed model
-Data collection worksheet (attached)
-Timer
-Thermometer
-Peer evaluation sheets (attached)

Objectives:

-Students will collect and record sufficient data from their models (solar and wind energy).
-Students will document their understanding of the project and its relation to the research.
-Further enrichment: Students will analyze how their data could be improved, what bias is seen in the data, and what went well during data collection. This should be communicated and documented.

Lesson Plan:

Data collection- Students will collect data from their constructed products and fill in the accompanying data tables.

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set	The teacher will help students run equipment, and make sure that all equipment is calibrated. The teacher should assess student collaboration during this process.	Students will test projects and troubleshoot any issues related to the solar oven and the wind anemometer.
Activating Learning Strategy	The teacher should foster collaboration during data	Students will gather data and fill in accompanying data

	collection. In anticipation of malfunctioning equipment, the teacher should be ready to mix groups that may need more support during data collection.	tables for the solar energy and wind energy. *See "Data Tables" sheet in the project packet,* ***Appendix,*** *page 75*
Cognitive Learning Strategy	The teacher will distribute the data analysis sheets. The teacher will want to provide students with a model for data analysis. This can be in the form of sentences that students should use to analyze their data.	Students will analyze data and determine efficiency of energy collection. This will be the group's evidence for their presentation regarding which energy they believe is most suitable for their region of the U.S. *See "Data Analysis" sheet in the project packet,* ***Appendix,*** *page 76.* *One sheet should be filled out for each of the two types of energy.*
Summarizing activity	The teacher will reference the objectives, and check for understanding by the students by checking data collection, assessing understanding, and monitoring peer evaluation. Class discussion should be encouraged by the teacher with rephrasing, extension of student feedback, and further reflection of student input.	Students will fill out the Ticket Out The Door (TOTD) slip. Each member of the team is required to fill out a slip. *See "Peer evaluation slip" in the Project Packet,* ***Appendix,*** *page 77* Students should spend the last couple minutes of class discussing what successes and failures they had during project design.

Name:___________________________________ Date:_______________

Earth Science Lesson #4, 5, 6

Supply List

Directions: Fill in the blanks below as part of your analysis of the equipment needed to collect renewable energy.

Your partner(s): ______________________________________

____

Renewable energy you are studying: ____

Supplies needed	**Quantity**

Name:____ Date:____________________
Earth Science- Mr. Johnson Peer evaluation

Directions: Answer the prompts below <u>for each partner.</u> Using the scale, circle 1 through 5 to rate your partners.

Partner 1 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Partner 2 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Day 7 Lesson Plan- What does the data we collected mean?

Rationale:

In this lesson, students will learn about the collection of hydro (electric) power. Students will be required to build models related to hydropower, collect data, and decide which region of the U.S. is suitable for hydropower. Students will continue to be assessed on their ability to collaborate during construction and analysis of their project design.

Materials needed:

-Completed model
-Data collection worksheet (attached)
-Timer
-Thermometer
-Peer evaluation sheets (attached)

Objectives:

-Students will collect and record sufficient data from their other models (hydroelectric and geothermal energy).
-Students will document their understanding of the other model(s) in the project and its relation to the research.
-Further enrichment: Students will analyze how their data could be improved, what bias is seen in the data, and what went well during data collection. This should be communicated and documented.

Lesson Plan:

Data collection- Students will collect data from their constructed products and fill in the accompanying data tables.

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set	The teacher will help students run equipment, and make sure that all equipment is calibrated. The teacher should assess student collaboration during this process.	Students will test projects and troubleshoot any issues related to the hydropower water wheel and the geothermal conductor.

Activating Learning Strategy	The teacher should foster collaboration during data collection. In anticipation of malfunctioning equipment, the teacher should be ready to mix groups that may need more support during data collection.	Students will gather data and fill in accompanying data tables for the hydropower water wheel and the geothermal conductor. *See "Data Tables" sheet in the project packet,* ***Appendix,*** *page 75*
Cognitive Learning Strategy	The teacher will distribute the data analysis sheets. The teacher will want to provide students with a model for data analysis. This can be in the form of sentences that students should use to analyze their data.	Students will analyze data and determine efficiency of energy collection. This will be the group's evidence for their presentation regarding which energy they believe is most suitable for their region of the U.S. *See "Data Analysis" sheet in the project packet,* ***Appendix,*** *page 76.* *One sheet should be filled out for each of the two types of energy.*
Summarizing activity	The teacher will reference the objectives, and check for understanding by the students by checking data collection, assessing understanding, and monitoring peer evaluation. Class discussion should be encouraged by the teacher with rephrasing, extension of student feedback, and further reflection of student input.	Students will fill out the Ticket Out The Door (TOTD) slip. Each member of the team is required to fill out a slip. *See "Peer evaluation slip" in the Project Packet,* ***Appendix,*** *page 77* Students should spend the last couple minutes of class discussing what successes and failures they had during project design.

Data Table 1. Wind data- Anemometer Lesson # 6, 7, 8

Day	1	2	3
Revolutions per minute (RPM)			
Power (watts) Divide RPM by 1.5, multiply by 750			

Data Table 2. Solar power- Solar oven

Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature (°F)															

Data Table 3. Hydropower- water wheel

Day	1	2	3
Revolutions per minute (RPM)			
Power (watts) Divide RPM by 1.5 then multiply by 750			

Data Table 4. Geothermal power- Simulated hot spring

Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature of water (°F)															
Temperature of metal bar (°F)															

Name:__________________________________ Date:_______________
Earth Science- Mr. Johnson Lesson #8, 9

Data Analysis

1. Create a line graph using the two variables that you measured during your data collection:

2. What is the relationship between the two variables?

3. Based on the relationship, does the data represent an energy that is worth utilizing? Why or why not?

4. Does this type of energy seem suitable to your region of the United States? Why or why not? Reference your research!

Name:____ Date:____________________
Earth Science- Mr. Johnson Peer evaluation

Directions: Answer the prompts below <u>for each partner.</u> Using the scale, circle 1 through 5, to rate your partners.

Partner 1 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Partner 2 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Day 8 Lesson Plan- How does our data relate to the real world?

Rationale:

This lesson is the final phase of phase 2 of PjBL (English and Kitsantas, 2013). Students will study the final type of renewable energy, geothermal energy. Students will gather data, analyze the results, and begin to organize all data for communication to their peers. Evaluation of their collaboration as a group will be done on an individual basis in this lesson, as well as with the whole class. The teacher will lead a class discussion at the very end of class for students to evaluate themselves and their peers through phases one and two. It is essential that students not only reflect on their content understanding, but also reflect on their strengths and weaknesses throughout the lesson.

Materials needed:

-Completed model
-Data collection worksheet (attached)
-Timer
-Thermometer
-Peer evaluation sheets (attached)

Objectives:

-Students will collect and record sufficient data from all of their models
-Students will document their understanding of the project and its relation to the research (continued).
-*Further enrichment: Students will analyze how their data could be improved, what bias is seen in the data, and what went well during data collection. This should be communicated and documented.*

Lesson Plan:

Data collection- Students will continue/ finish collecting data from their constructed products and fill in the accompanying data tables.

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set	The teacher will help students run equipment, and make sure that all equipment is calibrated. The teacher should assess student collaboration	Students will test projects and troubleshoot any issues related to all four types of renewable energy.

	during this process.	
Activating Learning Strategy	The teacher should foster collaboration during data collection. In anticipation of malfunctioning equipment, the teacher should be ready to mix groups that may need more support during data collection.	Students will gather data and fill in accompanying data tables for all four types of renewable energy. *See "Data Tables" sheet in the project packet,* ***Appendix,*** *page 75*
Cognitive Learning Strategy	The teacher will distribute the data analysis sheets. The teacher will want to provide students with a model for data analysis. This can be in the form of sentences that students should use to analyze their data.	Students will analyze data and determine efficiency of energy collection. This will be the group's evidence for their presentation regarding which energy they believe is most suitable for their region of the U.S. *See "Data Analysis" sheet in the project packet,* ***Appendix,*** *page 76.* *One sheet should be filled out for each of the two types of energy.*
Summarizing activity	The teacher will reference the objectives, and check for understanding by the students by checking data collection, assessing understanding, and monitoring peer evaluation. Class discussion should be encouraged by the teacher with rephrasing, extension of student feedback, and further reflection of student input.	Students will fill out the Ticket Out The Door (TOTD) slip. Each member of the team is required to fill out a slip. *See "Peer evaluation slip" in the Project Packet,* ***Appendix,*** *page 77* Students should spend the last couple minutes of class discussing what successes and failures they had during project design.

Data Table 1. Wind data- Anemometer Lesson # 6, 7, 8

Day	1	2	3
Revolutions per minute (RPM)			
Power (watts) Divide RPM by 1.5, multiply by 750			

Data Table 2. Solar power- Solar oven

Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature (°F)															

Data Table 3. Hydropower- water wheel

Day	1	2	3
Revolutions per minute (RPM)			
Power (watts) Divide RPM by 1.5 then multiply by 750			

Data Table 4. Geothermal power- Simulated hot spring

Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature of water (°F)															
Temperature of metal bar (°F)															

Name:___________________________________ Date:________________
Earth Science- Mr. Johnson Lesson #8, 9

Data Analysis

1. Create a line graph using the two variables that you measured during your data collection:

2. What is the relationship between the two variables?

3. Based on the relationship, does the data represent an energy that is worth utilizing? Why or why not?

4. Does this type of energy seem suitable to your region of the United States? Why or why not? Reference your research!

Name:____ Date:____________________

Earth Science- Mr. Johnson Peer evaluation

Directions: Answer the prompts below <u>for each partner.</u> Using the scale, circle 1 through 5 to rate your partners.

Partner 1 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Partner 2 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Day 9 Lesson Plan- What did we learn about renewable energy and collaboration?

Rationale:

This lesson is the beginning of two days within phase 3 of PjBL as explained by English and Kitsantas (2013). Students will organize their results and their discussion and prepare a presentation that is formatted to teach the class their research, their modeling of their understanding of the content, and their ability to meet the aspects of PjBL. This is arguably the most important phase of PjBL. Students must exhibit their learning throughout the unit. Students will do this by reflecting on an individual basis, group basis, and class basis. The teacher must encourage collaboration and communication with questions and discussion points.

Materials need:

-Data sheets (attached)
-Computer
    -Microsoft Word
    -Microsoft PowerPoint
-Peer evaluation sheets (attached)

Objectives:

-Students will prepare a mini-presentation that addresses their research and project.
-Students will reflect and document their ability to meet the unit objectives and collaborate effectively.
-Further enrichment: Students will use the class website to share their presentation online.

Lesson Plan:

Data analysis and presentation preparation

Lesson section (subtitle)	Teacher actions	Student actions
Anticipatory set	The teacher will help each group choose which renewable energy they should present on.	Students will review research on specific area of the United States *See Research essays and worksheets from earlier in the unit*
Activating Learning Strategy	The teacher will provide students with resources to	Students will organize data, determine if data collection

	determine which region of the U.S. is a reasonable option for their particular renewable energy.	method was effective, and decide which renewable energy would be best for their region of the country. *See "Data Analysis" sheet in the project packet,* ***Appendix,*** *page 76.* *One sheet should be filled out for each of the two types of energy.*
Cognitive Learning Strategy	The teacher will record which students will have which responsibilities during the presentation. This will be assessed during the presentation and recorded as part of the students' overall unit grade.	Students will delegate responsibilities during their presentation to the class including what will be said, who will discuss what parts, and whether their presentation fits within the time constraint (5 minutes)
Summarizing activity	The teacher will check student presentation for accuracy and logical explanations. The teacher will look to assess each student's participation during the lesson.	Students will fill out the Ticket Out The Door (TOTD) slip. Each member of the team is required to fill out a slip. *See "Peer evaluation slip" in the Project Packet,* ***Appendix,*** *page 77*

Name:_________________________________ Date:_______________
Earth Science- Mr. Johnson Lesson #8, 9

Data Analysis

1. Create a line graph using the two variables that you measured during your data collection:

2. What is the relationship between the two variables?

3. Based on the relationship, does the data represent an energy that is worth utilizing? Why or why not?

4. Does this type of energy seem suitable to your region of the United States? Why or why not? Reference your research!

Name:_________________________________ Date:_______________
Earth Science- Mr. Johnson Lesson #9

Directions: Answer the following questions so that you have a general outline of what you are going to present to your classmates.

Group members:

Which renewable energy are you presenting on?

Which state/ region of the United States did you pick that was suitable for the renewable energy you researched?

What materials did you use to build your model?

How did you collect data? Share the actual data you collected as well.

What do you conclude about your findings/ the renewable energy you researched for your specific area?

Name:_______________________________________ Date:____________________
Earth Science- Mr. Johnson Peer evaluation

Directions: Answer the prompts below **<u>for each partner.</u>** **Using the scale, circle 1 through 5 to rate your partners.**

Partner 1 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Partner 2 name:____

On task and responsible for his/her task during the project:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Collaborated and respected all ideas developed by group:

1: never 2: rarely 3: sometimes 4: mostly 5: always

Day 10 Lesson Plan- Project presentation and reflection

Rationale:

In this final lesson of the unit, materials will be gathered by each student/ group. Students will share their presentation with the class in a final attempt to collaborate in a way that displays their learning throughout the unit, and their ability to work together towards a common task. The rest of the class, along with the teacher, will asses each groups' presentation. The teacher will collect and assess all documents related to the unit to give the students a grade for the separate sections of the unit, as well as an overall grade for the unit.

Materials need:

-Data sheets (attached)
-Computer
    -Microsoft Word
    -Microsoft PowerPoint
-Peer evaluation sheets (attached)

Objectives:

-Students will communicate their research and their data analysis with the class.
-Students will discuss their strengths and weaknesses as a group in investigating the various renewable energy sources.
- *Further enrichment: Students will finish their online website version of their presentation, and design a rubric for other group online presentations.*

Lesson Plan:

Students present data and rationale to the class. Each group should address the criteria listed in "*The Presentation" section of the Project Packet*

- Your names, your class period, and the date
- The State that you decided to study
- The renewable energy source you chose to research
    - Some of your findings about the renewable energy in that particular State (2-3 facts)
    - Why you chose that specific renewable energy source
- The model that you built
- The data collected by your model
- Does your data meet the criteria? Why do you think it did/did not meet the criteria?

- What could you do differently in this project to make it better?
- What successes did you have as a group? What could you improve upon as a group?

See the "Presentation criteria" worksheet at the end of the Project Packet.

(Note: there will be eight groups presenting their findings. Each group will have 3-5 minutes with 30 seconds of transitions. These presentations should be done within one 40-minute class period.)

Unit Plan Reflection

This unit plan is designed to implement the tenets of Project-Based Learning (PjBL) in a manner that will help students learn the content specific to the unit, as well as learn to collaborate and engage in authentic learning. I feel that, with adaptations and reiterations, this unit can be extremely effective in guiding students toward self-regulated learning as well as strong collaboration to learn about renewable energy sources. The objectives of each day's lesson, as well as the overall objectives of the unit, will be met with extreme success, as students take charge of their own learning, and the learning of their peers around them. The demand for accountability that this PjBL unit provides is a paramount aspect of PjBL that should provide students with, not only a solid understanding of the content, but a sound understanding of the importance of meeting objectives and collaborating to meet a common goal. I feel very strongly about the positive aspects of PjBL; furthermore, it is my opinion that this unit plan is theoretically and practically sound in guiding students towards genuine and effective learning.

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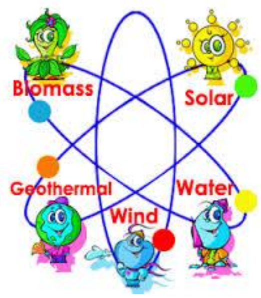
Appendix

This appendix contains the project packet, related documents, and evaluation documents that the teacher will distribute to each student at the beginning of the unit.

Name:______________________ Date:____________
Earth Science- Mr. Johnson Lesson #1

Renewable Energy- Which is the "Best"???



Background information: For years, humans have used conventional fuels, fossil fuels, and conventional electrical energy to power their cars, homes, and other technology. Recently, alternative forms of energy have been discovered. These forms of energy are known as renewable energy. Renewable energy is energy that comes from sources that can be naturally replenished *in our lifetime.* Examples of renewable energy are sunlight, wind, tidal energy, hydropower (water), and geothermal heat.

Objective: In this project-based assignment, the student will take the role of a scientist. Students will work in groups of three. Each student group will follow along in the scientific method in determining which renewable energy source would best fit a designated area of concern. Students will research the multiple renewable energy sources and resources, build and test a model for that renewable source, and explain why that renewable source best fits a certain area of concern.

General Vocabulary:

Renewable energy
Fossil fuels
Sustainability
Non-renewable energy

The Scientific Method

Ask a Question (Which sustainable energy is best for your area of the United States?)

- Solar energy
- Wind energy
- Geothermal energy
- Hydroelectric energy

Do Background Research (What is the area like? What sources are available? Which source of renewable energy would be most abundant?)

- West coast- winds, geothermal vents, open areas
- East coast- winds, high discharge rivers, streams, and waterfalls

Construct a Hypothesis ("__________ power will work best in ______________ because __________________")

Test Your Hypothesis by Doing an Experiment (Build a model to collect/ harvest energy)

- You can build:
    - A solar oven
    - Solar panel
    - Wind vane/ windmill
    - Thermometer
    - Hydroelectric generator

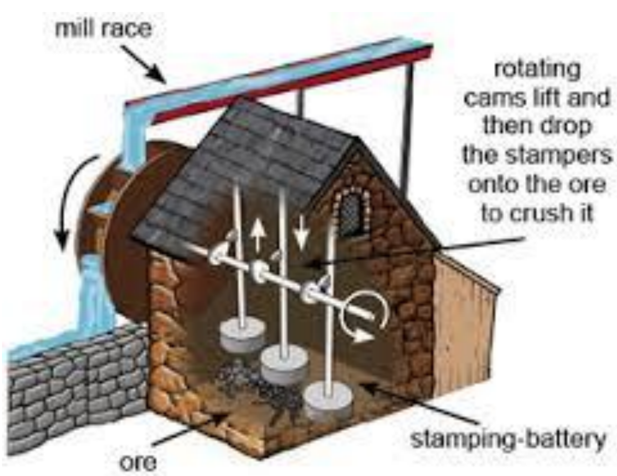
Analyze Your Data and Draw a Conclusion (Did your model meet the expectations? Why or why not?)

Communicate Your Results (Present your project to the class)

- Create a PowerPoint that illustrates all of the above information
- Present to the class in 10-15 minutes all of your findings

Part 2- The Project Lesson #4

- Analyze a prototype of a model that you will build. Write down the supplies needed and the quantity of each material.
- Build a model to capture the type of renewable energy that you chose for your State.
- You must make a supply list
- The model must capture energy and you must collect data on your model
- If you want to build a model that captures energy from a bigger source (something that you cannot get to) then you must model the conditions that match the source you are attempting to capture energy from.
    - For example: If you choose hydroelectric power for New York State, and you choose to capture energy from the Niagara Falls, you must look up the discharge of the Niagara Falls. Your model should be a smaller-scaled version of the Niagara Falls in that the discharge of your model represents the discharge of the Niagara Falls.
- You should collect data at least three different times (over the course of three class periods)
- Create/ fill in a data sheet that collects numerical data of your model
- Your data sheet, along with a **single page (max)** analysis of your model can be one document



https://www.google.com/search?q=water+wheel&newwindow=1&client=firefox-a&rls=org.mozilla:en-US:official&channel=nts&source=lnms&tbm=isch&sa

Part 3- The Presentation Lesson #9, 10

Create a PowerPoint presentation that includes the following criteria:

- Your names, your class period, and the date
- The State that you decided to study
- The renewable energy source you chose to research
    - Some of your findings about the renewable energy in the State (2-3 facts)
    - Why you chose that specific renewable energy source
- The model that you built
- The data collected by your model
- Does your data meet the criteria? Why do you think it did/did not meet the criteria?
- What could you do differently in this project to make it better?

https://www.google.com/search?newwindow=1&client=firefox-a&rls=org.mozilla%3Aen-US%3Aofficial&channel=nts&tbm=isch&sa=1&q=collaboration&oq=collaboration&gs_

Name:___________________________ Date:_____________

Earth Science- Mr. Johnson Lesson #4

Make a Pizza Box Solar Oven

Objective: Students will follow the procedure below to build their own version of a solar oven. This solar oven is a project in which students are trying to rationalize the collection of solar energy in our area of the New York and the United States.

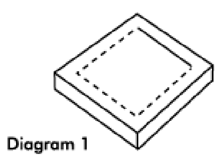
Materials:

- Recycled pizza box
- Black construction paper
- Aluminum foil
- Clear plastic (heavy plastic laminate works best)
- Exacta or scissors.
- Pen/Pencil/Marker
- Tape
- Newspaper

Procedure:

Step 1

Have the student place the construction paper on top of the box and trace the outline. The tutor should then cut three slits, leaving the edge closest to the box opening.



Step 2

Form a flap by gently folding back along the uncut line to form a crease. (Diagram 2) Cut a piece of aluminum foil to fit on the inside of the flap. Smooth out any wrinkles.

Step 3

Measure a piece of plastic to fit over the opening you created by forming the flap in your pizza box. The plastic should be cut larger than the opening so that it can be taped to the underside of the flap.

Step 4

Measure a 2nd piece of saran wrap. Tape this piece to the top side of the box. (This will make a total of two layers of saran wrap with a small layer or air in between). It is important to get these seals tight!

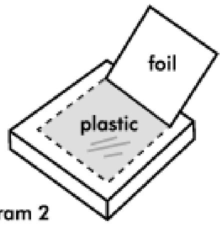


Diagram 2

Step 5
cut another piece of aluminum foil to line the bottom of the pizza box and carefully glue into place. Cover the aluminum foil with a piece of black construction paper and tape into place. (Diagram 3) Note: the layer of Al foil underneath the black is optional.

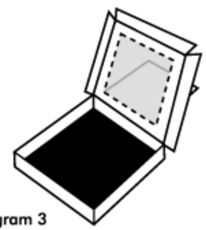


Diagram 3

Step 6
Line the sides of the pizza box with rolled newspaper for added insulation.

Step 7
Close the pizza box top (window), and prop open the flap of the box with a wooden dowel, straw, or other device and face towards the sun. (Diagram 4). (Mike and I found that the prop in not necessary with these boxes). Adjust until the aluminum reflects the maximum sunlight through the window into the oven interior.

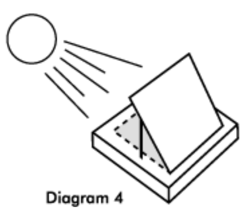


Diagram 4

Step 8

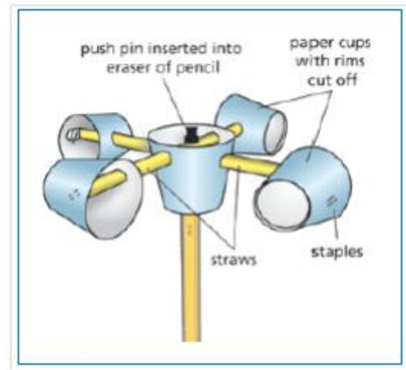
Data collection and analysis- Collect data using the appropriate data table on the "data table worksheet". Answer the analysis questions in consideration of the solar oven as an effective way for collecting solar energy, and as an effective collection of renewable energy in your particular region of the United States.

(This document has been adapted from Stanford University, http://www.re-energy.ca/*pdf*/*Solar*%20Heat%20LP%20formatted.*pdf)*

Name:______________________ Date:__________
Earth Science- Mr. Johnson Lesson #4

Building an anemometer

Materials:



- 5 three ounce paper Dixie Cups
- 2 soda straws
- pin
- scissors
- stapler
- sharp pencil with an eraser

Procedure: ***Refer to the picture to the right while following the procedure***

1. Take four of the Dixie Cups and use a sharp pencil to punch one hole in each, about a half inch below the rim

2. Take the fifth cup and punch four equally spaced holes about a quarter inch below the rim. Then punch a hole in the center of the bottom of the cup.

3. Take one of the four cups and push a soda straw through the hole. Fold the end of the straw and staple it (or tape it) to the inside of the cup. Repeat this procedure for another one-hole cup and the second straw.

4. Slide one cup and straw assembly through two opposite holes in the cup with four holes. Push another one-hole cup onto the end of the straw just pushed through the four-hole cup.

5. Bend the straw and staple it to the one-hole cup, making certain that the cup faces the opposite direction from the first cup. Repeat this procedure using the other cup and straw assembly and the remaining one-hole cup.

6. Align the four cups so that their open ends face in the same direction either clockwise or counter-clockwise around the center cup.

7. Push the straight pin through the two straws where they intersect.

8. Push the eraser end of the pencil through the bottom hole in the center cup. Push the pin into the end of the pencil eraser as far as it will go. Now your anemometer is ready for use!

9. Attempt to calculate the 'wind speed' of a gust of wind by blowing into your anemometer. Blow for 4 seconds, and attempt to count how many times your anemometer spins around in those four seconds.

10. Fill in the data table on the "data table worksheet" and analyze your data.

Name:__________________________ Date:_____________

Earth Science- Mr. Johnson Lesson #5

Hydropower- Building a water wheel

Objective: In this experiment, you will look to build a water wheel that can collect data in terms of revolutions per minute (RPMs). Your group will need to decide if the water wheel is an efficient method for collecting energy from the movement of water.

Procedure:

1. Down one short side of the foam board or cardboard, make a straight line two inches from the edge of the foam board. Divide this section into ten 1.5 inch segments. These will be your paddles. Using the protractor, trace out two circles on the foam board, marking the center of the circle using your protractor. This is where your axle will connect the two halves of your water wheel. (The axle is the shaft that the wheel rotates on.)
2. To make the stand for your water wheel, you may consider tracing this pattern. Just click on the link to download and print it. The size of this pattern works best for a water wheel with a 6 inch diameter (the size made with a 6 inch long protractor). Cut out the pattern along the solid black lines, NOT along the dotted lines. Trace two of the legs on the foam board, and two of the support beams. (The support beam is the rectangle.)
3. Cut out the water wheel pieces from the foam board or cardboard with scissors or a box cutter. ***Have a teacher help you if needed!***
4. On one of the halves of the water wheel, use the protractor to mark the placement of the paddles at about 40 ° intervals. Angle the paddles toward the center of the wheel like the spokes of a bicycle. Use glue or pins to attach the short end of the paddles so that they line up on the markings on the wheel. Attach the other half of the water wheel to the paddles. Carefully insert the skewer through the centers of the wheels. Set the water wheel aside.
5. To make the stand for the water wheel, take one leg and use pins or glue to attach the support beams to the leg at the dotted lines. Take the other leg and attach it to the support beams opposite of the first leg. To increase support for your stand, you can attach the optional base to the bottom of the stand.
6. Place the water wheel on the stand, with the axle (skewer) resting in the grooves at the top of the stand.
7. Place your water wheel in the kitchen sink. Open the faucet so that a small amount of water runs out and spins the wheel. Experiment with the placement of the wheel under the stream of water and the amount of water coming out to see what works best.
8. Watch your water wheel at work by attaching a bucket to the axle. Punch holes into the top of the egg carton section with a skewer so that a piece of string can be looped through to make a handle. Attach a larger piece of string from the handle of the bucket to the axel of the water wheel. Experiment with how much weight can be lifted in the bucket using the power of water.

(This experiment has been adapted from *homesciencelearning.com*)

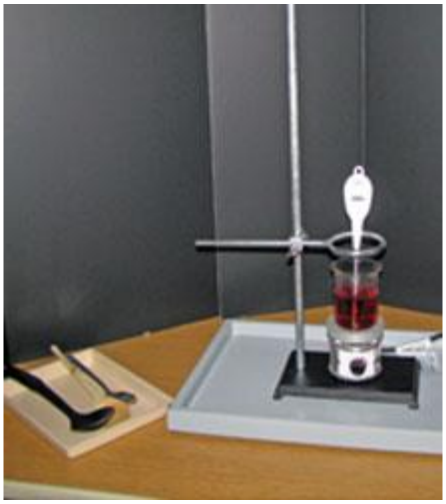
Name:___________________________________ Date:_____________
Earth Science- Mr. Johnson Lesson #5

Geothermal Energy- Heat conduction

Objective: In this activity, your group will simulate the capturing of geothermal energy, which is energy produced from heated vents that eject heat from the interior layers of Earth. Geysers, springs, and other geothermal vents, create an environment where superheated water can be transferred into energy. Your group will attempt to collect temperature data of different conductors of heat.

Materials:
- Large plastic cooking spoon
- Large wooden spoon
- Large metal spoon
- 3 large beakers
- Timer
- 3 Talking Thermometers
- Hot plate

Procedure:
1. Fill each beaker approximately ¾ full of water. And place one spoon in each beaker.
2. Take a temperature reading at the beginning for each beaker to ensure that they all start at the same temperature.
3. Observe what each spoon feels like.
4. Next place one beaker with a spoon in it on each of the hot plates.
5. Take temperature measurements of each spoon every minute for 15 minutes.
6. Set the temperature of each hot plate to medium and time for 2 minutes.
7. Turn off the hot plates and carefully remove the spoons to a heat resistant surface. Carefully touch each spoon. (An adult supervisor should check the temperature of the metal spoon before allowing students to touch it. It should feel warm but not hot enough to cause a burn.)
8. Describe the way each spoon felt. Which one was coolest which one was warmest? Why do metal cooking spoons have wooden or plastic handles?



(This activity has been adapted from *www.perkins.org)*

Rubrics

The following pages are rubrics to be used to assess student progress and understanding throughout the unit. These rubrics are created for formative assessment throughout the unit, as well as a summative assessment at the end of the unit.

Rubric- Written essay

	4	3	2	1	
Criteria	Essay covers all bullet points for criteria, and explains how renewable energy relates to particular area of U.S.	Essay is missing one piece of criteria from bulleted list or does not address the relationship between a renewable energy and a particular region of the U.S.	Essay is missing two or three pieces of criteria from bulleted list. Relationship between renewable energy and a particular region of the U.S. is vague or missing.	Essay is missing more than three pieces of criteria from bulleted list. Relationship between renewable energy and a particular region of the U.S. is vague or missing.	
Content	The renewable energy that is being discussed is clearly stated. Research information is clearly stated and cited.	The renewable energy that is being discussed is missing one or two important points. Research information is confusing or vague.	The renewable energy that is being discussed is missing three or four important points. Research information is confusing and/or not cited.	The renewable energy that is being discussed is missing more than four pieces of important information. Research information is confusing, missing and/or not cited.	
Quality	Depth of knowledge is clearly understood, and essay displays clear scope in research and understanding of content.	Depth of knowledge is lacking, and/or essay displays a limited scope of understanding.	Depth of knowledge is significantly lacking, and/or essay displays a disconnect between content understanding and research.	Depth of knowledge is not displayed through essay and essay shows no strong relationship between content and research.	
Presentation	Essay is one page, typed, double spaced, 12 point font, and Times New Roman.	Essay is missing one piece of criteria listed in previous column.	Essay is missing two pieces of criteria in first column.	Essay is missing more than two pieces of criteria in first column.	

Rubric- Mini presentation

	4	**3**	**2**	**1**	
Presentation	Students show understanding of content through presentation	Students show a lack of understanding of content through presentation	Students show a significant lack of understanding of content through presentation	Students show no understanding of content or do not complete presentation	
Participation	Each student in group participates in presentation	Each student participates, but participation is limited or skewed	Students fail to distribute responsibilities in presentation evenly or at all	Majority of group does not present on content or understanding	
Collaboration	Students work together to prepare and execute presentation	Students work together to prepare or present on presentation but do not do both processes as a group	Students do not show ability to collaborate on aspects of the mini presentation	Preparation or presentation is not completed in a group manner or at all	

Final assessment of overall project

	5	4	3	2	1	Score
Project Design	The project meets all of the criteria listed in each phase. A model is built and tested, data is collected, and the project is presented in a coherent fashion	The project meets most criteria listed in each of the phases. A model is built but data is incoherent or inconsistent, project is presented with minor points of confusion	The project meets half of the criteria, the model and data is unclear, and research is unclear	The project research, data, and presentation do not meet most of the criteria within the project packet	The project does not align with most or all of the criteria within the research, building, and presenting phases	
Data collection	Data tables are complete and sensible for each of the four types of renewable energy	Data tables are mostly complete for each of the four types of renewable energy	Data tables are incomplete, and all data is inconsistent or non-existent for at least one type of renewable energy	Data tables are incomplete, and all data is inconsistent or non-existent for at least two type of renewable energy	Data tables are incomplete, and all data is inconsistent or non-existent for at least three type of renewable energy	
Research and written essay	All research prompts and sheets are completed, written essay meets all criteria	Research prompts are incomplete and missing one criterion from essay	Research prompts are incomplete or inaccurate and two criteria missing from essay	Very few research prompts are covered and essay is lacking most criteria	No evidence of research and all essay criteria is missing or inaccurate	
Collaboration	Students work together throughout entire project and complete all responsibilities	Students work together in most component, but one responsibility is lacking	Students work together throughout only half of the project components	Students show little collaboration and are missing responsibilities	Students do not collaborate during project and miss many or all responsibilities	
Peer evaluation/ Reflection	Group completes a peer evaluation for each other every day of the unit. Reflection in presentation is present and clear	Group completes a peer evaluation for each other at least 7 days, and reflection is present and clear	Group completes a peer evaluation for each other at least 5 days. Reflection in presentation is present but unclear	Group completes a peer evaluation for each other at least 3 days. Reflection is also lacking and unclear	Group does not complete any peer evaluation or cover any reflection piece of their project and collaboration	
					Total	