Differentiating Science Instruction for All Learners in Problem-Based Learning

Brian Battle
*The College at Brockport*, bbatt1@u.brockport.edu

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Differentiating Science Instruction for All Learners in Problem-Based Learning

By

Brian Battle

December, 2015

A culminating project submitted to the Department of Education and Human Development of The College at Brockport, State University of New York in partial fulfillment of the requirements for the degree of Master of Science in Education
Differentiating Science Instruction for All Learners in Problem-Based Learning

By

Brian Battle

APPROVED BY:

__________________________________________  ______________________________
Advisor                                          Date

__________________________________________  ______________________________
Chairperson, Education and Human Development     Date
Abstract

One of the biggest challenges for science teachers today is teaching a challenging science curriculum to an extremely diverse population of students in terms of abilities, interests, backgrounds, and learning styles. Making this task even more difficult is the timeframe in which teachers have to teach all students the entire science curriculum. The pressure teachers currently face to complete this task may result in the replacement of the quality of instruction for the quantity of instruction. This thesis aims to provide teachers a way to offer quality science instruction to a diverse group of learners through a hybrid approach of direct and guided instruction and project-based learning (PBL). The purpose of implementing these different instructional approaches is to provide all learners with an opportunity to learn the required science curriculum by providing a similar foundation of knowledge from which all learners can build off through PBL activities. Similarly, utilizing the opposing instructional approaches allows students of differing learning styles to learn the content in differing ways, while also providing skill building opportunities in the areas of communication, problem-solving, teamwork, and time management. The sample unit plans provided in this project demonstrate the transition students make in becoming more independent learners through the utilization of scaffolding provided throughout the unit. The goal is to provide teachers with a framework of hands-on, engaging instruction that is suitable for all learners and also provides them with the skills needed to be college and career ready.
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Chapter One: Introduction

Rationale

Teachers are continually striving to improve classroom instruction that will engage, motivate, educate, and give students the skills they will need to graduate high school and be successful in life after high school. This monumental challenge excites teachers to continually evaluate and reflect upon their teaching practices that will benefit all learners in the classroom. In an effort to keep up with the ever-changing educational standards such as the Common Core Standards and Next Generation Science Standards (NGSS Lead States, 2013), teachers recognize the huge challenge before them to develop engaging lesson plans that will teach all students the information that is necessary for passing high stakes tests, and be able to apply the content they have learned in real world situations. Added to this challenge, is an increasingly diverse population of students with differing learning styles and abilities. As a result, much research has been done concerning the effects that problem-based learning (PBL) has on students' learning science content.

While much research has been done regarding the effectiveness of PBL in science classrooms, there still is a lot of ambiguity in deciding whether it is the best instructional approach for teachers to utilize. In order to answer this question, teachers must take a backwards-design approach, and ask themselves what it is they want students to learn. Some researchers have concluded that students who learn in PBL environments may produce lower scores on tests that focus primarily on a student’s knowledge of content (Albanese & Mitchell, 1993; Vernon & Blake, 1993). Simmons & Klein (2007) noted that PBL students scored lower on national board examinations and other measures of knowledge than those in traditional lecture based learning (LBL) environments. In addition, Allen, Donham, & Berhnardt (2011), reported that PBL shows only modest benefits to student recalled content knowledge. Therefore, if the instructor’s goal is solely improving the student’s knowledge of content, the case for PBL over traditional teaching methods such as lecture based learning (LBL) is conflicting. However, if the instructor is aiming at improving students’ practical skills for the application of the content knowledge, PBL is an extremely useful teaching strategy. Allen et al. (2011) further noted that PBL enhances students’ ability to combine newly acquired knowledge with prior knowledge. Additionally, PBL supports the development of a range of “soft” skills, including research skills,
negotiation and teamwork, reading, writing, and oral communication. Lastly, students in the PBL curriculum expressed more positive attitudes toward learning science than students in traditional programs (Allen, Donham, & Berhnardt, 2011). In summary, PBL has been linked with improving student’s attitudes toward learning science, student’s performance on complex tasks, and increasing student’s retention of knowledge.

Piburin and Baker (1993) mentions that a major reason for students’ negative attitudes toward learning science is due to the complexity and abstract concepts being taught. Therefore, teachers need to utilize scaffolds and guided instruction to break these abstract concepts down more clearly to students, creating a stronger foundation of scientific knowledge for a student to build from. This research supports the fact that teaching instruction is a major reason for low interest and negative attitudes towards school science learning across the world today. Nolen (2003) argued that instructors cannot emphasize memorization over practical work in science learning, as this will promote students negative feelings toward science. However, if students learn science in a practical way, it may increase their interest in the subject by involving them in an authentic learning process, as opposed to being passive learners (Osborne & Collins, 2000). Similar results were also found in George’s (2006) study, which argued that when students are able to apply their scientific learning into their day-to-day activities their interest in science may rise. Thus, it is important to develop an instructional curriculum that enhances students’ interest and attitudes towards science (Tseng, Chang, Lou, & Chen, 2011).

As the research above shows, engaging students is vital in creating a learning atmosphere where students have a positive attitude toward learning science. PBL offers authentic instruction that has the ability to motivate, educate, and teach students skills that a traditional learning environment cannot. However, in order to see the beneficial outcomes of PBL, research needs to be conducted on the best ways to develop and implement a PBL environment in the science classroom that will benefit learners of all abilities. This literature review will look at differentiating instruction in inclusive classrooms utilizing PBL as the method of instruction. Building off this research, several PBL lessons will be created that incorporate the best practices for differentiating instruction for inclusive science that benefits all learners.
Significance of Project

Problem-Based learning has proven to be a successful method of teaching since it became widely used by medical educators in the 1950s and 1960s as a way to teach medical residents in a practical manner (Allen, Donham, & Bernhardt, 2011). Since then, many studies have shown problem-based learning to be effective in motivating students to learn, promoting retention of concepts, improving social skills, promoting problem-solving skills, and building new concepts from student’s prior knowledge. However, much of the research conducted to this point on PBL has been focused on those students considered to have higher academic skill sets (Preus, 2012). By focusing on this select group of students in our current educational system, many students are missing out on the benefits of an authentic learning opportunity that promotes scientific literacy. This project includes a PBL approach to teaching science to all students by incorporating various research-based scaffolding techniques into the curriculum. This project focuses on developing scaffolds into the PBL curriculum to ensure that all students can have the same opportunity to learn science in an authentic manner and be able to apply this learning in practical situations.

Definition of Terms

PROBLEM-BASED LEARNING (also known as Project-based learning) (PBL) - a student-centered pedagogy in which students learn about a subject through the experience of solving a problem.

SCAFFOLDS - tools, strategies, or guides that support students in gaining higher levels of understanding that would be beyond their reach without this type of guidance (Jackson et al., 1996; Saye & Brush, 2002).

"SOFT" SCAFFOLDS - dynamic supports that refer to the domain of teacher actions in support of learners' efforts at the moment of when a learner has a specific need (Berk & Winsler, 1995; Roehler & Cantlon, 1997; Saye & Brush, 2002).

"HARD" SCAFFOLDS - static supports that can be developed in advance based on anticipated or typical learner difficulties associated with a task (Saye & Brush, 2002).

INSCRIPTIONS - various types of transformations through which an entity becomes materialized into a sign, an archive, a document, a piece of paper, a trace (e.g., digital pictures, Web pages, and models) (Latour, 1999).
Chapter Two: Literature Review

Historical Background of PBL

PBL was formalized by medical educators in the 1950s and 1960s. The purpose was to help students learn the ever increasing content of medical knowledge while also teaching better problem-solving approaches. At this time, traditional approaches were based on the "bucket theory", a belief that placed students as receivers of knowledge passed on to them from previous instructors. Students would then be responsible for recalling such knowledge from memory when needed to solve clinical problems. (Allen, Donham, & Bernhardt, 2011). PBL was designed to address a major flaw of the bucket theory, when student’s “buckets” begin to “overflow” due to the overwhelming amount of information needing to be stored, as well as differing abilities of students carrying different sized “buckets”. Implementing a new approach by presenting realistic case studies for the purpose of learning, PBL demanded that students call on an integrated, multidisciplinary knowledge base (Wood, 1994).

Some research data suggested that PBL had little or no beneficial effect on student learning of content when testing for basic understanding (Allen et al., 2011). However, looking beyond strictly content knowledge shows gains from students in other areas. For example, studies showed students who participated in PBL frequently outperformed their traditional counterparts by having a higher ability to apply knowledge in their discipline post graduation (Allen et al., 2011). This suggests that PBL allows for greater retention of content knowledge due to having a better conceptual understanding, as opposed to just memorizing individual facts. The evaluation of PBL outcomes in the medical school setting (Albanese and Mitchell, 1993; Vernon and Blake, 1993) showed positive student attitudes about learning, with students frequently viewing PBL as both a challenging and a motivating approach.

Due to the success of PBL in the medical school setting, it eventually migrated into undergraduate science and engineering classrooms as a valid teaching approach. As PBL gained more attention as an effective teaching strategy, it gradually became implemented in high schools, middle schools, and even in children's instructional television programs to engage and teach at the same time. As PBL gained momentum in education, research began to focus on some of the relative merits of PBL and suggested that the most positive effects are seen with student’s understanding of the linkage of concepts, providing a broader foundation of content.
knowledge in which to build from (Gijbels, Dochy, Van den Bossche, and Segers, 2005). Other studies indicate a positive effect from PBL on the retention skills of students, noting that students in PBL remember more acquired knowledge compared with their traditional counterparts (Song, Grabowski, Koszalka, & Harkness, 2006).

Over the years, many educators began blending PBL elements with traditional teachings such as lecture-based learning (LBL) in an effort to gain the best results that are associated with each type of learning. Instructors tend to insert direct instruction, as well as whole-class discussion into the PBL cycle and integrate PBL problems intermittently throughout the course schedule, blending PBL instruction with LBL instruction (Allen et al., 2011). As Newman (2003) noted, this hybridization of PBL makes it “difficult to distinguish between different types of PBL and even to distinguish between PBL and other educational interventions” (p. 7) (Allen et al., 2011). As a result, PBL is a difficult topic to research in terms of the effects on student learning outcomes due to the variety and different interpretations teachers and researchers have on what constitutes the implementation of a PBL approach to learning.

**Differentiating Instruction in PBL**

One of the most challenging things facing teachers today is the need to differentiate instruction for such a wide range of learners in the classroom. Recently, there has been an undisputable increase in the number of students classified with a (SWD) in the classroom, and the SWD population continues to rise. Contrastingly, Trna (2014) reports that educational experts argue that about 2-3% (Mönks & Ypenburg, 2002) of students are exceptionally gifted. Therefore, instruction needs to be tailored to each learner so that all students are progressing in the classroom at a rate that is reflective of their ability. Research supports PBL as an effective method of instruction to support developmentally appropriate instruction (Song et al., 2006). Pedersen and Liu (2003) note that much of the PBL research has focused solely on gifted learners, making it difficult to document the effectiveness of PBL in an atmosphere with students representing a wide range of abilities (Simons & Klein, 2007). Due to the presence of both types of learners in the classroom, students who are gifted and students with disabilities, it is essential to look at scaffolding PBL instruction in a way that benefits all types of students.

According to the National Middle School Association (1995), students typically in grades 4 through 9 are in a transition period from concrete thinking to abstract thinking. It is important
to note, too, that developmental differences in students exist in the classroom when attempting to encourage reflective thinking in PBL environments (Song et al., 2006). Scaffolding allows for this differentiation in instructing students of varying levels of ability by modifying complex tasks in ways that make these tasks reachable, workable, and more appropriately within a student’s zone of proximal development (Rogoff, 1990; Vygotsky, 1978) (Choo et al., 2011).

There are different opinions about how resources or scaffolds should be used in a PBL curriculum (Taylor & Miflin, 2008). While some research supports that PBL curricula should be characterized by as little direct instruction as possible, others believe that there should be more structure in the curricula (Choo et al., 2011). Realistically speaking, the amount and type of scaffolding needed to support instruction in a PBL environment relates directly to the ability of the students in the classroom. For this reason, Banchi & Bell (2008) broke PBL down into four types, each with different levels of teacher assistance (guiding students in the process with worksheets, directed questions, and explicit instruction at times such as mini-lectures) (Choo et al., 2011). The first and most restricted level of PBL is 'confirmation', where the question, procedure, and solution are all defined by the teacher through heavy scaffolding for the student. The second and less restrictive level is 'structured', where the question and procedure is defined by the teacher through scaffolding, but the solution is not. Thirdly, is 'guided', where the only thing scaffolded by the teacher is the question. Lastly, 'open' PBL is where nothing is scaffolded by the teacher and the student is free to ask and research at his discretion. Therefore, when differentiating instruction in the science classroom, it is important to keep these levels of PBL in mind, and assign different levels appropriately for each learner.

Hmelo-Silver et al. (2007) discusses a few different types of scaffolding and how these scaffolds help learners with disabilities. The first, are considered "scaffolds that structure complex tasks or reduce cognitive load" (p. 101). An example of such a scaffold may include a journal to keep track of the facts of the case, hypothesis, learning issues, and an action plan, which helps remind the group of what they need to do. This type of scaffolding provides a way for students to document and organize their thinking so that they are not responsible for keeping all of this information in their memory. Another example of this type of scaffolding is to structure a task in ways that allow the learner to focus on certain aspects of the task that are relevant to the learning goals (Hmelo-Silver, 2006; Salomon, Perkins, & Globerson, 1991). For example, scaffolding can reduce cognitive load by making students responsible for a specific job
on the team, such as a note-taker (Quintana et al., 2004) (Hmelo-Silver et al., 2007). The second type of scaffolding Hmelo-Sivler et al. (2007) discusses is "scaffolds that make disciplinary thinking and strategies explicit." These types of scaffolds help learners with disabilities by giving them explicit information at certain times throughout the PBL instruction to ensure there are no misconceptions and to help students who may be struggling with the content keep pace with the rest of the class. Examples of these types of scaffolding would be fill in the blank worksheets, models shown by the teacher, or concept maps created by the teacher to show the students to help them with making connections between concepts.

Research has been conducted on the effects of using both "hard" and "soft" scaffolds to guide the students in learning content and developing problem solving skills. Hard scaffolds can be conceptual guides for the learner toward ideas to consider during the problem-solving process through notes, worksheets, graphic organizers, etc. While soft scaffolds refer to supporting the students through teacher feedback, peer collaboration, wait time, etc (Simons & Klein, 2007). Simons & Klein (2007) state that hard scaffolds can be used to supplement soft scaffolds by giving visual direction to students so that the teacher can be more available to provide soft scaffolds to the students that need them. Simons & Klein (2007) also point out that scaffolds are meant to only augment teacher support and not replace it. Therefore, soft scaffolding throughout the learning process is key to the success of PBL, especially for supporting reflection, guidance, and feedback to the learners. The teacher's ability to determine when to use scaffolding and what type of scaffolding to use are keys to implementing a PBL classroom.

**Recommendations for using Hard Scaffolds in PBL**

While Allen et al. (2011) suggested in his research that scaffolds such as worksheets may not play a significant role in enhancing students’ learning within the social constructivist framework of problem-based learning, other studies have refuted this claim. In fact, when used appropriately, hard scaffolds can provide learners with an organized framework of concepts that help the student link together main ideas. For instance, Wu (2006) states, "material resources, including textbooks, curriculum materials (e.g., guideline sheets), learning technologies, and the inscriptions students constructed early in the unit, also played an important role in supporting students engagement in inscriptive practices. For example, the textual descriptions provided by
Model-It helped students realize that the relationship between heat from the sun and turbidity was not a simple causal relationship" (p. 863).

Research shows that graphic organizers and modeling are excellent hard scaffolds that can help student link "big ideas" together to formulate understanding (Kaldernberg, Therrien, Watt, Gorsh, Taylor, 2011). Concept maps or E-charts are types of graphic organizers that can be used as scaffolds to help learners grasp main ideas and see the interconnectedness of the content. Kaldernerg et al. (2011) reported that concept maps developed by the students helped them establish links between relevant pieces of information and identify key concepts among many supporting facts. Akçay (2009) also states, "Maps also helped students understand that science is organized around essential concepts, which are developed through nonlinear associations of information." (p. 30) (Gallagher et al, 1995; Greenwald, 2000; Plucker & Nowak, 1999).

The use of models helps visual and kinesthetic learners see the relationship between certain things. Wu & Krajcik (2006) noted that through the construction of models, students’ confusion about certain concepts was revealed, thus correcting for misconceptions. Models had the ability to transform students’ conceptual knowledge into a series of causal relationships, which eventually led to students' emergent understandings of a specific topic (Wu & Krajcik, 2006).

Writing to learn is another form of hard scaffold that has been found to be effective when implemented in a PBL environment. Journal writing has been found to help students develop reflective thinking skills that are imperative to learning in the PBL classroom. Andrusyszyn and Daive (1997) report that reflective journal writing can be a major piece of PBL that promotes reflection in students and also links new ideas to existing concepts (Song et al., 2006).

Lastly, using digital pictures and mnemonic devices are also effective scaffolds to use in PBL units for learners to develop conceptual thinking, especially visual learners. Wu et al. (2006) reported, "by providing rich visual information, digital pictures could help students make predictions and construct links among concepts, observations, and features represented in the pictures." Another useful tip Wu et al. (2006) gives for using digital pictures to learn in PBL, is to make annotations on the picture, and include date and time so that students may use these pictures as evidence to demonstrate meaningful reasoning practices when needed.
Mnemonic devices also help visual learners by helping the student identify key concepts or vocabulary with a picture or image in their mind. Mastropieri and Scruggs (1998) describe the use of mnemonics as an effective method to organize new ideas so they can be stored and retrieved from a learner’s memory more effectively, which is a source of difficulty for most students with disabilities.

The common theme for all of these hard scaffolding techniques is that they help student’s link big ideas together. Once students begin to understand big ideas, they are able to link concepts together and then build off this knowledge to help them better understand the supporting concepts. When teaching students with disabilities, the key focus should be on developing the students’ understanding of these big ideas and key concepts as the foundation that supporting ideas of conceptual knowledge will be built from.

**Recommendations for using Soft Scaffolds in PBL**

While research gives mixed results on the implementation of hard scaffolds, the research on the importance of soft scaffolds is unanimously in support of the role of teacher, tutor and collaborative small group learning, which are key features of PBL. Choo et al. (2011) with reference to prior studies, reinforce the view that soft scaffolds are critical for student learning in a PBL environment. Choo et al. (2011) states, “Tutors should have the relevant content knowledge to guide students throughout the process of solving the problem by asking open-ended questions to facilitate them” (p. 523) (Hmelo-Silver 2004b; Hmelo-Silver and Barrows 2008; Maudsley 1999; Yee et al. 2006). Soft scaffolds can be as simple as giving a student “wait time” to answer a question. Most students with learning disabilities struggle with processing delays that require them to take extra time in answering questions. When wait time is given by the instructor, the students feel less pressure to give an answer, and more freedom to think about their answer. On the other hand, soft scaffolds can be as intricate as requiring more teachers in the classroom to facilitate student learning. For instance, giving specific feedback and asking guiding questions are evidence-based scaffolds that promote reflective thinking in the student. While these things are generally not hard to do, it is hard to find the time in a typical class period to speak with every student and provide such feedback, especially to the auditory learners, who learn best through discussion. As Preus (2012) noted, giving specific feedback and making specific comments that built on the students’ own understanding of their work encouraged
students to take risks because their confidence had grown in their understanding of key concepts. By using open-ended questions and directed questions, students are able to learn through their mistakes while being guided through a learning process in which they feel engaged and have ownership over.

Another soft scaffold that should be implemented in a PBL classroom is flexible grouping, in which teachers strategically place students in different groups depending on specific needs for a particular task. Flexible grouping can help distribute the cognitive load put on students and give them better opportunities to practice solving complex problems (Allen et al., 2011). Other soft scaffolding techniques Preus (2012) mentioned in the study were building on students’ interests, keeping students on pace with supports and/or modifications when applicable, and reminding students of main concepts. These scaffolding techniques can be developed both inside and outside the classroom when the general education and special education teacher collaborate to plan effective strategies for the learners.

One scaffolding strategy that can be implemented into group projects is de Bono’s (1995) Six Thinking Hats. This approach is designed to encourage participants to investigate problems from a number of different perspectives. In this activity, each hat represents a different style of thinking (BradburyJones & Herber, 2011). Smith & Cook (2012) explain the method behind the Six Thinking Hats;

The white hat is used to assess the amount of information the group currently has, gaps in the knowledge, and how to acquire additional information. The red hat represents an emotional response to a particular decision, while the black hat focuses on the risks involved with a particular decision. With any decision there will be positive benefits, and the yellow hat promotes this type of thinking, while the green hat encourages creativity, allowing learners to “think out of the box” when looking for a solution. Finally, the blue hat is worn by a leader who could be a member of the group, the facilitator, or both. When ideas are drying up, (s)he is responsible for re-directing the thinking back to a previous hat, allowing a new discussion to take place (de Bono, 1995) (p. 133).

This is another example of how teachers can reduce students’ cognitive load by giving them a specific job to do as part of a team. As a result, the student may feel less overwhelmed by focusing on one part of the project. The student can then learn from his peers by observing their methods to complete their specific jobs. Overall, research shows that when students are given scaffolds by the teachers and provided with the appropriate resources, they were able to make
claims, to represent conceptual understandings, and to engage in thoughtful discussions in a problem-based learning environment (Wu & Krajcik, 2006).

**Potential Benefits of Differentiating PBL**

There are numerous reasons that many students struggle to learn science concepts in the classroom. First and foremost, is student’s lack of motivation toward learning science (Allen et al., 2011). Secondly, students can struggle with retention of important concepts needed to see important connections and make sense of these 'big ideas' (Kaldernberg et al., 2011). Thirdly, students often don't have the skills necessary to self-reflect on their own learning (Preus, 2012). Lastly, students have trouble applying knowledge they have learned to complex, real-world problems due to a combination of weak problem solving and teamwork skills, and the unfamiliarity of solving ill-structured problems (Bulu & Pedersen, 2010). Therefore, in order to give all students an equal opportunity to learn, all of these problems need to be addressed in the classroom. Successful implementation of PBL is critically dependent on the instructor’s ability to use both hard and soft scaffolds appropriately to bring about students’ active learning and knowledge construction (Choo et al., 2011).

There is little debate as to whether PBL is more effective than lecture-based learning (LBL) to improve students’ positive attitudes toward learning, increase reflective thinking and problem-solving skills, and improve students' ability to work in a group. Ferreira & Trudel's (2012) research of group discussions in PBL groups result in a positive influence on students’ interest in the subject matter, which may indirectly lead to an increase in the students’ motivation level to learn (Lohfeld et al., 2005). Another study compared the effects of PBL on students' intrinsic and extrinsic motivation in the PBL context with typical class activities (Pederson, 2003). Students involved in the PBL unit showed significantly higher intrinsic motivation than did their counterparts in the traditional activities. This was attributed to a greater opportunity for collaboration and student ownership of the content through problem-based learning (Simons & Klein, 2007).

Student's difficulty retaining a wealth of science information is another roadblock student’s encounter when learning science. Simons & Klein (2007) found that PBL students seemed to have superior long-term recall, since they allegedly held a deeper understanding of the content being taught. When concept maps are integrated into PBL units, they allow the student
opportunities to focus on main concepts and find relationships between these concepts, promoting understanding rather than encouraging memorization. From understanding these key concepts, students then have a better chance to build off their prior knowledge. Song et al. (2006) reports that PBL has positive cognitive effects on the activation of prior knowledge, recall of information and causal reasoning (Dolmans and Schmidt 2006; Hmelo 1998).

Reflective thinking is promoted by ill-structured, authentic, and complex tasks. Students think reflectively when immersed in a learning environment that prompts them to investigate complex problems using multiple forms of information to find a solution (Stepien & Pyke, 1997). Students must reflect on their understanding of an issue, acquire new knowledge to help in developing a solution, and think about how their new knowledge can be linked with prior knowledge to solve a problem in order to find success in the PBL environment. Therefore, through reflection learners generate concepts and develop the new knowledge needed to generate a solution to the given problem (Barrow, 1998).

Another outcome of successful PBL implementation are the students' ability to practice lifelong learning behaviors (Smith et al., 2005) to solve real-world, ill-structured problems by distinguishing relevant information, and to effectively use their time and resources effectively in order to solve such problems (Allen et al., 2011). In addition, research provides adequate support that PBL is an effective way to teach students the collaborative skills they need to be beneficial members of a team. Findings by Song et al. (2006) imply that middle-school students prefer a learning environment in which they can collaborate with their classmates to prompt their reflective thinking. Therefore, a successful PBL environment incorporates cooperative learning strategies that foster effective teamwork, as well as a push for everyone to work to keep team members engaged and on track (Johnson, Johnson, and Smith, 1998). PBL, when used with effective scaffolding, develops all of these factors that help students become more effective authentic problem solvers.

In an effort to meet the College and Career Readiness Standards set forth in the CCS as well as the learning standards in the NGSS addressing all of the difficulties mentioned above that students' struggle with in the classroom will finally give students an equal opportunity to learn content more deeply and become more prepared for life after high school.
Problem-based learning, as with all other teaching methodologies, does come with its share of critics. Firstly, critics argue that PBL has shown no effects on learning content knowledge in a subject matter. Secondly, teachers can make the argument that PBL is too time consuming to cover the required curriculum in a single school year. Lastly, some critics will say that some students have negative attitudes toward PBL, and would prefer a traditional, LBL classroom.

On the whole, Choo’s et al. (2011) research shows that scaffolds in general and PBL classroom has demonstrated varying levels of impact on student learning achievements. Some studies have shown effectiveness of scaffolds in supporting student learning (Cho and Jonassen 2002; Roehler and Cantlon 1997; Simons and Klein 2007). For example, Simons and Klein (2007) examined the impact of scaffolding and student achievement levels in a PBL environment, whereby students were subjected to both hard and soft scaffolds. Results revealed that those students who were given access to scaffolds performed significantly better in the post-tests, compared to the students with no scaffolds provided. The findings indicated that scaffolds positively influence student inquiry and performance in a PBL classroom. Contrastingly, the results of Choo’s et al. (2011) study showed no significant difference in level of student achievement in regard to the PBL or LBL classroom. A possible reason for this discrepancy could be a result of educators having a generalized idea of “scaffolding”, (Hammond, 2008) meaning educators may not have had a clear definition of scaffolds and how to implement them to achieve successful teaching (Verenikina, 2008). However, even if there are mixed results in the acquirement of knowledge through PBL instruction, students predominately benefit from the soft skills, such as communication and collaboration skills that are obtained in the PBL classroom. This makes PBL environment still a more attractive option to teaching than LBL. Akçay (2009) makes this clear in his report that PBL students do as well as their counterparts from traditional classrooms on national exams, but are in fact better practitioners of their professions due to the practical skills they have learned through PBL (Hmelo-Silver, 2004).

All teachers are overly aware of the time constraints that are placed upon them to cover a certain amount of content for high stakes testing. Therefore, one of the biggest concerns for implementing a differentiated PBL classroom is the lack of time to not only plan the instruction, but to guide students through such a collaborative process. These concerns are compounded in a
classroom of predominantly low achieving students. The results of Simons & Klein’s (2007) 
study suggested there should be continuing concern for low achievers in complex PBL 
environments, as poor post-test results of low achievers suggest they were left behind throughout 
the problem-solving process. This implies more effective means of scaffolding for low achievers 
are needed through the PBL process (Simons & Klein, 2007). Many additional studies found 
that when students were rushed through the PBL process it became counterproductive to the 
goals they set forth for the students. Additionally, the students felt pressured and frustrated by 
the time constraints that limited their ability to understand key concepts and provide valuable 
input for suggesting solutions to the problem presented. Simons & Klien, (2007) reported that 
many low-achieving students responded to the open-ended questions that the PBL project was 
difficult and that they did not have enough time to complete it, meaning the students needed 
much more time and help to successfully achieve the targeted objectives.

Kirschner et al. (2006) suggest that problem-based learning (PBL) is less effective and 
efficient than instructional approaches because of the minimal direct instruction. While PBL is 
considered by many as an effective teaching strategy to engage most students, there are still other 
students that may prefer a more traditional teaching approach. Akçay (2009) reports, problem-
based learning relies on an ill-structured problem, which is messy and complex in nature, and has 
no simple, fixed, formulaic, "right" solution. Many students have difficulty with this 
unstructured environment, and therefore may struggle with PBL, at least at first.

While all of these arguments are valid, PBL can be modified, adapted, and combined 
with other types of instruction in order to maximize the potential of all learners. It is important 
to note here that teaching effectively can not be considered as "one size fits all", but instead, 
numerous approaches need to be applied in order to meet all students needs in the classroom. 
The Next Generation Science Standards seem to support this notion, as it calls for deeper 
learning of less science content, as opposed to more coverage but in less depth. According to the 
NGSS, "the Framework identified a smaller set of Disciplinary Core Ideas... [to] focus on deeper 
understanding and application of content" (NGSS Lead States, 2013).

**Implementation**

It is my intention to develop a PBL approach that will implement the recommendations of 
evidence based research in order to take advantage of the positive aspects of PBL while
overcoming the potential barriers to PBL. The PBL approach will be a lesson plan utilizing all of the recommendations researched above and, in doing so, provide all students with an equal opportunity to learn and apply science.

First off, it should be noted that that heavy scaffolding needs to be in place for students with disabilities to ensure they are keeping pace with instruction and understanding main concepts. This includes, at times, direct instruction, or mini-lectures, that many people do not associate with PBL. This type of PBL would be most appropriate for students with disabilities or those who need more intensive support, which was describe above as the type of PBL known as 'confirmation' (Trna, 2014). PBL instructors can plan for intervals of class discussion or mini-lectures to help students navigate conceptual impasses, to dig more deeply into certain topics, or to find useful resources. Instructors can also enter team discussions to listen and pose questions (Hmelo-Silver, Duncan, and Chinn, 2007). Additionally, they can also use student facilitators to extend their instructional reach to ensure all students are receiving valid formal assessment of their learning. (Choo et al., 2011) For gifted students, 'guided' or 'open' forms of PBL would be more appropriate. These types of support may be classified as a more inquiry-based approach where the student has much more freedom to make mistakes and learn from these mistakes. Therefore, it is imperative that when implementing my PBL lesson, continuous formal assessments of the students is taking place to ensure each student is utilizing the PBL approach that is appropriately placing each student in the zone of proximal development.

One of the most challenging aspects of teaching PBL is guiding students’ learning, but not controlling it to the point that the problem is no longer ill-structured (Reiser, 2004). Successful PBL instruction still allows students to develop independence in their inquiry. It is important to simplify components of the task through scaffolding, but keep expectations of the learning objectives the same for every student, and not accept superficial solutions and explanations (Reiser, 2004). Effective PBL instructors are able to create good problems based on clear expectations for learning in order to maximize the potential of the learners. The goals of learning should include not only conceptual and procedural knowledge but also the flexible thinking skills that prepare students to be lifelong learners (Hmelo-Silver, et al., 2007). Therefore, rubrics shall be given to all students prior to the assignment task as a major part of the PBL instruction that takes place to ensure learning objectives are reachable for all students. In
essence, the degree of scaffolding will change from student to student, but the learning objectives will not.

Instructors must facilitate group discussion and good collaboration skills within the PBL classroom. For example, students must be taught to avoid the temptation of moving too quickly to a conclusion or simply agreeing to one suggested by other group members. The teams that perform best are those that generate and sustain consideration of multiple alternatives, engaging in and sustaining “substantive conflict” (Allen, et al., 2011). In addition, assessing individual students can be difficult in group settings. In order to ensure group work is shared equally and effectively among group members, peer evaluation can be utilized to give students individual assessments on their contribution to the team. Formative assessment through observations by the teacher and teacher aide's in the room can also help ensure each student is working to the best of her ability to contribute for the good of the team.

The common theme in the research of differentiating PBL instruction for all learners was focusing on the big ideas and essential questions of the unit. Rather than learning isolated facts, all students should be expected to learn how concepts are related to each other and how they connect beyond the classroom. Obviously, these big ideas will need to contain more explicit scaffolding for some students more than others. Preus (2012) gives suggestions such as strategy instruction; concept maps, modeling of assignment tasks; mini-lectures; reading; listening or viewing content with quick writes and discussion; and individual conferences with the teacher, which are strategies that can be effective for students both with and without disabilities. Naturally, some students will finish projects quicker than others, which can be accounted for by giving these students extra responsibilities that may deepen their understanding of the content (Kincaid & Jackson, 2006).

In closing, the most successful PBL classrooms in the research noted very little difference between how teachers treated students with and without disabilities. Differentiation, such as scaffolding and flexible grouping, was provided to anyone who needed it, regardless of their classification. Content should not be watered down for those with disabilities, nor there any separation in the class between students with disabilities and those without. Grouping of students can be done in terms of skill level, with each team member having the ability to bring something positive toward accomplishing the set goal(s). This can include pairing students with different skill sets together, pairing stronger students with weaker students, or pairing students
with similar abilities together and differentiating the scaffolds given to each group (i.e. higher achieving group gets less scaffolding while lower achieving group gets more scaffolding). Effective PBL instruction also provided the heaviest scaffolding during the brainstorming stage of the project. This approach allowed students who needed more time for processing information to feel less pressure and frustration from the start of the unit (Preus, 2012).

Furthermore, it is important to keep in mind that PBL is a learning process for both the instructor and the learner. It is not realistic, nor fair to expect both parties to see all the benefits of this type of instruction the first time it is implemented. It takes practice from both sides to begin to understand the best approaches and expectations associated with this type of learning.
Chapter Three: Project Design

Overview

This project is designed to include a variety of inclusive PBL activities that will offer an authentic learning experience for all students within the Earth Science curriculum. The units in this project were chosen because they mesh well with authentic, current, real world problems. The problem-based activities will align with the Next Generation Science Standards and the NYS Common Core Learning standards. The goal of this project is for all students to achieve the learning targets set forth in the NYS standards by providing struggling learners the support they require, and gifted students the freedom they need to expand upon their learning. While many of the activities presented in this project may not look like a typical PBL unit plan, they should be considered problem-based learning due to their authenticity, inquiry-based format, and cooperative learning components. What set this project apart from typical PBL projects are the varying degrees of scaffolds implemented in the lessons to support all learners through the process of PBL, as well as the additional learning opportunities given to students who demonstrate mastery of the learning standards and required skills of the unit in an accelerated time frame. Every problem-based learning activity will aid the learners in answering the ‘essential content questions’ of the unit to develop each student’s content knowledge as well as reinforce the ‘big ideas’ for each unit to assess each student’s authentic learning skills.
Scaffolding Pyramid for Typical PBL Unit:

“Soft” Scaffolds

Peer Teaching

Additional Assignments

"Hard Scaffolds"

Inquiry-Based Learning

"Higher Thinking” Questions

Reflective Questions

Structured

"Hurdle” Help

Writing to Learn

Flexible Grouping

Guided Worksheets

Direct Instruction

Reflective Questions

Specific Feedback

Driving Questions

Wait Time

Models

Organization

Graphic Organizers

On Task Reminders

Mnemonic Devices

Copy of Class Notes

"Hard Scaffolds"
**PBL UNIT #1: GLOBAL WARMING**

- **Grade level:** 9th Grade Earth Science

- **Topic/Case Study:** Global Warming: Should actions be taken in response to the threat of global warming?

- **Time Period:** 10-12 days, 45 minute class periods

- **Teacher Rationale:**

  This PBL unit plan will engage students to educate themselves and become more involved in current scientific issues such as global warming. I have learned through my personal experience in teaching, as well as in my research for this project, that all students learn best when they become active learners. This unit plan not only gives meaning to the importance of learning about global warming by connecting it to student’s everyday lives, but it also puts the emphasis on students being active in working toward a solution. After each student is given the necessary background knowledge of global warming to begin the project, the teacher then only acts as a facilitator guiding the students through the learning process.

  In this unit, the students will learn that science cannot be studied as an isolated subject, but blends into history, politics, mathematics, and other content areas. Additionally, this assignment is an open ended project that will allow students the freedom and ownership to find a solution for themselves in an attempt to engage all students. Students will improve their problem-solving abilities by learning to analyze problems through many different lenses. Students will also be able to see first-hand the cause-effect relationships on the issue of global warming through their research. Teamwork, leadership, and organizational skills will also be pivotal for students to learn and practice as they proceed through this unit.

  Lastly, the unit is built for all learners to progress at different paces, with re-teaching available for students who require it and additional assignments and research activities to build upon their knowledge of the essential questions for students who move at a faster pace. Therefore, the PBL unit is intended for all learners to be successful in learning the scientific standards as well as the skills mentioned above.

- **Overview:**

  The debate on global warming continues to be an issue among scientists, politicians, and concerned citizens from all over the world. There are, however, a few points in this controversial issue that can be agreed upon by the supporters from both sides of the issue; 1) science is tied directly to important political decisions, and (2) important decisions need to be based off facts as opposed to biased interpretations of the facts. This unit plan aims at providing students with the current facts that we know of today regarding global warming and climate change, and allows the student to make their own interpretations based on such data. Students will learn to identify and evaluate valid evidence that can be used to support causal relationships (i.e. atmospheric increase in carbon dioxide levels vs. global warming).

  Over the course of this unit, students will utilize many different resources, including both hard and soft scaffolds to educate themselves on the issue of global warming. The knowledge the students gained will be on display in a team debate regarding whether actions should be taken in response to the threat to global warming. Debate ideas will be given to all students to help
make arguments more clear, creative, and engaging. In some instances, students will be asked to play “devil’s advocate” in order to equally divide teams for the debate.

The goal of this PBL unit plan is to provide sufficient scaffolds for learners that need additional support, as well as additional resources for students who understand the big ideas quickly and want to learn more about this topic through further research. Therefore, by the end of the unit, all students will understand the big ideas of the unit, and some students will have learned even more about the implications of these big ideas.

- **Next Generation Science Standards:**
  HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems.
  HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.
  HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.
  HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
  HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
  HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

- **Big Ideas**
  1. Information can be presented in ways that are intended to mislead the audience.
  2. Decisions should be made based on valid evidence, not hearsay, persuasion, or other outside influences.
  3. Respect each other’s opinions, even if we don’t understand them.
  4. Create change through education, by example, and being an advocate for change.
  5. Climate change is attributed to many factors, including the effect of greenhouse gasses produced by human activity.

- **Essential Content Questions:**
  1. What is the difference between climate change and global warming?
  2. What are some causes of global warming?
  3. What are some causes of climate change?
  4. What are the major greenhouse gasses?
  5. How do greenhouse gases affect the Earth’s atmosphere?
  6. What problems would global warming cause for life on Earth?
  7. Why could global warming be a problem?
8. Can global warming be prevented or minimized? Why or Why not?

- **Hard Scaffolds implemented:**
  - Graphic Organizers
  - Models
  - Writing to Learn
  - KWL Chart
  - Reflection Notes
  - Main Ideas from Guided Questions
  - Frayer Model - Vocabulary
  - Driving Question
  - Additional Assigned Research
  - Videos/Pictures

- **Soft Scaffolds implemented:**
  - Direct Instruction
  - Organizational Aides (Job Responsibility, Task Guidelines, Guided Schedule, Task Guideline)
  - Re-Teaching
  - Specific Feedback
  - Flexible Grouping
  - Reflective Questioning*
  - Extended Time*
  - Hurdle Help* (Modified Assignments & student to teacher interactions)
  - Peer Teaching*

*See ‘Teacher Recommendations for Implementation’ for an explanation of these soft scaffolding techniques.

- **Recommendations for teacher implementation:**
  
  During the first 4 days of this unit, the teacher should use a lot of direct instruction with the students to ensure adequate background knowledge is obtained before the PBL project is assigned. With this background knowledge, students will be less inclined to “give up” right from the start in becoming so confused at the assigned PBL task. After the 4th day, students shall be encouraged to begin their team work on this project, but for those students that don’t have a confident understanding of the main ideas presented in class, re-teaching will be available to them either by a teacher or co-teacher (PBL unit works best with co-teaching). After a few days of re-teaching content (if needed), the teacher’s role then switches to a facilitator. As a facilitator, the teacher asks teams reflective questions, provides “hurdle help” for those students that require a little more direction, and motivates students to find as much information on this topic as possible before making any decisions. Lastly, it is important to adjust the time for this unit as necessary. Extended time may be warranted if students need more time for research or more time to plan and organize final presentation. Teacher will assess the day to day productivity of teams and make a decision about the timeline for this project. A day after the presentations should be left for student reflection of the PBL unit that will provide valuable input for both the student and teacher.
**Unit plan outline:**

**11-DAY UNIT CALENDER**  
9th Grade Level (45 minute periods)  
PBL Unit: Global Warming

<table>
<thead>
<tr>
<th>DAY 1: NATURAL WORLD PROBLEMS CONCEPT MAPPING</th>
<th>DAY 2: INTRODUCTION TO THE GREENHOUSE EFFECT</th>
<th>DAY 3: HOW DO WE INTERPRET DATA?</th>
<th>DAY 4: INTRODUCTION TO PBL ASSIGNMENT... DEBATE EXPECTATIONS</th>
<th>DAY 5: RESEARCH / RETEACHING</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Pre-Assessment (10 min)</td>
<td>● Warmup: 3 possible consequences of global warming (5 min)</td>
<td>● KWL chart (5 min)</td>
<td>● Share interesting graphs students found with class (5 min)</td>
<td>● Students begin filling out Venn diagram or finishing Day 4 activities (10 min)</td>
</tr>
<tr>
<td>-Complete the concept map individually for different world problems (Extreme weather, Wildfires, Flooding, Droughts)</td>
<td>● Review of laboratory experiment through class discussion and notes (10 min)</td>
<td>● Review of graphing on reflection notes (10 min)</td>
<td>● Analyze debate examples with students on notes and class discussion (20 min)</td>
<td>● Students who feel (or teacher feels) need re-teaching on concepts can see teacher for review (20-25 min)</td>
</tr>
<tr>
<td>● Teamwork (10 min)</td>
<td>● Modeling Activity Instruction (10 min)</td>
<td>● Introduction to distorted graphs (10 min)</td>
<td>● Introduce PBL Assignment (15 min)</td>
<td>● Students work on Day 5 Task Guideline activities (10-15 min)</td>
</tr>
<tr>
<td>-Complete the concept map in teams using available resources</td>
<td>● Students work on creating models and write-ups (20 min)</td>
<td>● Class discussion on graph examples in reflective notes (10 min)</td>
<td>● Students begin work on PBL assignment (5 min)</td>
<td></td>
</tr>
</tbody>
</table>
DAY 6: RESEARCH / RETEACHING
- Students continue working on activities indicated on Task Guideline sheet (45 min)
- Re-teaching available from teacher for students who need it

DAY 7: RESEARCH
- Students continue working on activities indicated on Task Guideline sheet (45 min)

DAY 8-9: RESEARCH
- Students continue working on activities indicated on Task Guideline sheet (45 min)

DAY 10: CLASS DEBATE
- Class presents projects to debate both sides of global warming (45 min)
- Hmwk: Regents questions on global warming (15 min)

DAY 11: CLASS REFLECTION
- Group Peer Evaluation (5 min)
- Self Reflection (5 min)
- Class Reflection (20 min)
- Review Hmwk (15 min)

Day 1 through 11

DAY 1 - GLOBAL WARMING: Natural World Problems Concept Mapping

Lesson Objective(s): The learners will create concept maps to identify how climate change, specifically global warming, can affect life on Earth.

New Vocabulary Words:
Global Warming
Climate Change

Websites / Resources Used:
http://www.livescience.com/37057-global-warming-effects.html

Anticipatory Set: Students are given 10 minutes to complete concept maps based on their background knowledge of specific current natural problems the world is facing today.

Purpose: The purpose of this lesson is to teach students the causal relationships regarding climate change and their effects on ecosystems on the Earth.

(Explore): Students are then invited into teams by natural world problems assigned (teacher gives thought into assigning worldly problems to each student to ensure productive group work (i.e. flexible grouping). Students are given 10 minutes to talk their ideas out and share with group members. Lastly, students are given an additional 10 minutes to research their assigned problems with iPads, computers, and other available resources.

(Explain): Teacher asks students to share some of the notes they took in their teams during work time. A commonality the teacher points out to students is that these assigned problems are all associated with climate change allegedly caused by global warming. Teacher notes that the word allegedly is used here because there is much debate as to whether global warming is actually happening, why it may be happening, and the effects of it. Teacher explicitly discusses
the differences between global warming and climate change so there is no confusion or misuse of 
the terms moving forward.

(Elaborate/Extend): This part of the lesson plan will be delayed to be included in the following 
day’s lesson. Now that teacher has set up the importance of this topic by relating it to real world 
current events, the next day’s lessons will be the explanation of greenhouse gases and how they 
play a major role in global warming.

Assessment (Evaluate): Teacher makes an informal pre-assessment on the student’s prior 
knowledge of the effects of global warming during first 10 minutes of lesson by observing 
student’s fill out concept maps independently. Teacher makes another informal assessment of 
students collaborating in groups and researching their topic. Lastly, teacher will assess the 
finished concept maps and reflection questions as a ticket out the door to see if student 
understanding occurred.

Adaptations within the Inclusive Classroom: In this lesson, there are a few things that have 
been adapted to make it a more successful learning experience for all students. First, the teacher 
seats students so that all are able to listen and see the teacher clearly. Second, the directions to 
the assignment are given both verbally and written on the handout, as well as modeled to the 
class to accommodate many different learning styles. Third, the teacher assigns pre-determined 
groups to be used in this activity so that students who understand this material can work with 
students who do not comprehend it as fast, or ELL (English Language Learners) students will be 
paired with students who can help them express their ideas (i.e. flexible grouping). The group is 
monitored to work together, and if there are any physical components in this activity that cannot 
be completed by a student, another group member can complete that part, and the other student 
may work on a separate piece of the activity.
Global Warming – Day 1 Concept Mapping Natural World Problems

Directions: You will be assigned with a current problem our planet is facing today from the list below. You will then write your assigned problem in the center box of your concept map and begin the steps below as directed by your teacher.

Natural World Problems... flooding, droughts, wildfires, extreme weather events

Steps:
1) Fill this graphic organizer out using only your current knowledge of the problem you picked (10 min).
2) Team up with other students who picked the same problem and combine ideas to help you complete the concept map (10 min)
3) Use computers and iPads available in the classroom to aid your team in completing this concept map (10 min). You may try this website as a starting point… http://www.livescience.com/37057-global-warming-effects.html

Name: ___________________ Date: __________

Problem:

1) Why a problem?
2) What is causing it?
3) Specific Examples?
4) Solution(s)?
Global Warming – Day 1 Reflective Notes

Vocabulary:

**Definitions:**

- **Global Warming:**
  - Definition: A gradual increase in overall temperature of earth’s atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, chlorofluorocarbons, and other pollutants.
  - This is a weather forecast for a specific area. Global warming is over a long period of time and is the overall warming of the Earth’s atmosphere. Think **Global!**

- **Climate Change:**
  - Definition: Changes in wind, precipitation, the length of seasons as well as the strength and frequency of extreme weather events like droughts and floods.
  - Example: The Ice Ages (World scale)
  - Decrease in yearly average precipitation amount of New York state from 2000 to 2015 (Regional scale)
  - Non-Example / Notes: Difference between Global Warming and Climate Change is…
  - *Global warming causes climates to change.*

**Discussion Questions (ticket out the door):**

1. What problems would global warming cause for life on Earth?
2. What is the difference between climate change and global warming?
DAY 2 - GLOBAL WARMING: Introduction to the Greenhouse Effect

Lesson Objective(s): The learners will create models to demonstrate their knowledge on how the greenhouse effect warms Earth's atmosphere at a molecular level.

New Vocabulary Words:
- Greenhouse gases
- Greenhouse effect

Websites / Resources Used:
- https://sealevel.jpl.nasa.gov/files/archive/activities/ts1hiac1.pdf (Lab Activity in E.S. Lab)
- https://www.youtube.com/watch?v=BPJM_hCFj0
- https://www.youtube.com/watch?v=ZzCA60WnoMk

Anticipatory Set: Students are asked to write 3 potential consequences of global warming from previous day’s activity for a warmup activity and hand them in.

Purpose: The purpose of this activity is for students to demonstrate their understanding of how the greenhouse effect works using a 2D or 3D model based on their laboratory activity.

(Explore): Students explored how the greenhouse effect works in laboratory (see website referenced above for laboratory activity).

(Explain): Teacher explains process of greenhouse effect during laboratory activity as well as shows videos referenced above to clarify understanding. Class fills out reflective note taking sheet during class discussion of the major greenhouse gases and where they come from.

(Elaborate/Extend): Students work on developing a 2D or 3D model showing shortwave and longwave radiation that caused the atmosphere (inside the bottle) to warm through the greenhouse effect. As a supplement to this model, students need to write what is occurring in their models, explain how this contributes to a warmer atmosphere, and how an increase in greenhouse gases would affect the temperature of the atmosphere. See handout for specific guidelines.

Assessment (Evaluate): Teacher assesses student answers to the question posed in the anticipatory set. Teacher assess student learning in laboratory. Teacher assesses individual student models created and writing explaining the processes.

Adaptations within the Inclusive Classroom: In this lesson, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the students who require more support to create their 2D models can use the scaffolding worksheet attached to this lesson to get them started. Also, the gallery walk is intended for students to see all types of student created models that will help explain the process of the greenhouse effect that we couldn’t see during the lab experiment.
Vocabulary:

<table>
<thead>
<tr>
<th>Pictures</th>
<th>Definition: the physical process by which atmospheric gases allow sunlight to pass through, but also absorb infrared radiation from Earth’s surface. Thus the atmosphere acts like a heat-trapping blanket. Life as we know it could not exist on Earth without the warming produced by the greenhouse effect.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="http://facweb.bhc.edu/academics/science/harwoodr/NSC102/study/GreenHous.htm" alt="Greenhouse Effect" /></td>
<td>Greenhouse Effect</td>
</tr>
</tbody>
</table>

Example: What we did in E.S. lab!

https://www.bigelow.org/virtual/handson/greenhouse_make.html

Non-Example / Notes:
The greenhouse effect is only one of many factors affecting climate causing climate change.

<table>
<thead>
<tr>
<th>Pictures</th>
<th>Definition: a gas that contributes to the greenhouse effect by absorbing infrared radiation. Major sources are caused from burning of fossil fuels (man-made), and cow flatulence (farts) (natural).</th>
</tr>
</thead>
</table>

Example:
- Carbon Dioxide (CO₂)
- Methane (CH₄)
- Nitrous Oxide (N₂O)
- Water Vapor (H₂O) -gas form

Non-Example / Notes:
- Carbon (C)
- Water (H₂O) -liquid form
Global Warming – Day 2 Reflective Notes

During our discussion of greenhouse gases, fill in the following terms from the word bank. Words may be used more than once!

**Word Bank:**
- Methane (CH$_4$)
- Cow Flatulence (farts)
- Ozone (O$_3$)
- Carbon Dioxide (CO$_2$)
- Water Vapor (H$_2$O)
- Nitrous Oxide (N$_2$O)
- Burning fossil fuels*
- Deforestation
- Organic Waste Decay
- Agriculture
- Respiration (breathing)

*Fossil Fuels = Coal, Oil, & Natural Gas

<table>
<thead>
<tr>
<th>Natural greenhouse gases</th>
<th>Human enhanced greenhouse gases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Greenhouse Gas</strong></td>
<td><strong>Method</strong></td>
</tr>
<tr>
<td>Methane (CH$_4$)</td>
<td>cow flatulence (farts)</td>
</tr>
<tr>
<td></td>
<td>organic waste decay</td>
</tr>
</tbody>
</table>

If you missed any key parts of the discussion, or would like further information, use the URL below for more information…

Global Warming – Day 2 Classwork / Assignment

**Directions:** Use all available resources (computer, iPad, textbook, lab activity, notes) to create a 2D or 3D model that demonstrates how the greenhouse effect works at the molecular level. Your models will be graded on creativity, accuracy, clarity, and effort. You will need to show the following in your models; Sun, clouds, specific natural greenhouse gases, specific human enhanced greenhouse gases, long wave radiation, short wave radiation, any other information you feel is relevant.

Some Examples are shown below:

Example #1:

![Natural Greenhouse Effect](https://www.google.com/search?q=natural+greenhouse+effect&safe=strict&biw=1024&bih=643&noj=1&source=lnms&tbm=isch&q=human+enhanced+greenhouse+gases&spell=1&sa=x&ved=0ahukewj9xv7gsj6txiaiz4khf1sdvms_wuijypa&dpr=1&biw=1024&bih=643&safe=active&gws_rd=ssl#imgrc=WmslN9g5FnlM%3A)

Example #2:

![Human Enhanced Greenhouse Effect](https://www.google.com/search?q=human+enhanced+greenhouse+gases&spell=1&sa=x&ved=0ahukewj9oioao8jrj7u79t0khf1sdvms_wuijypa&dpr=1&biw=1024&bih=643&safe=active&gws_rd=ssl#imgrc=apJ_iAS0ixmbtM%3A)
Accompanying your model should be a well written description explaining what is occurring in the model you created. To aid you, the following questions should be answered in your writing:

1) How do greenhouse gases play a role in affecting the temperature of the atmosphere?
2) How would an increase in greenhouse gases play a role in affecting the temperature of the atmosphere?
3) Explain if the greenhouse effect is a “good” or “bad” phenomena (or both)? Explain.
4) What are the major greenhouse gases?
Global Warming – Day 2 Modified Classwork / Assignment

Directions: Use all available resources (computer, iPad, textbook, lab activity, notes) to create a 2D or 3D model that demonstrates how the greenhouse effect works at the molecular level. Your models will be graded on creativity, accuracy, clarity, and effort. You will need to show the following in your models; Sun, clouds, specific natural greenhouse gases, specific human enhanced greenhouse gases, long wave radiation, short wave radiation, any other information you feel is relevant). Feel free to use any of the unlabeled models shown below to get you started on your in your design. Label everything happening in the diagram, and add anything you feel necessary to complete the requirements of this greenhouse model.

Sources: http://www.enwin.com/kids/conservation/greenhouse_effect.cfm
DAY 3 - GLOBAL WARMING: How do we interpret data?

Lesson Objective(s): The learners will analyze various types of graphs to learn how to identify key information in the graph.

New Vocabulary Words:
Misleading (Distorted) Graph

Review of Vocabulary Words:
Direct Relationship
Inverse Relationship
Rate of Change

Websites / Resources Used:
None

Anticipatory Set: Students are asked to fill out a KWL chart on graphs (See handout below).

Purpose: The purpose of this lesson is to teach students how to research information that is relevant to their search, valid information, and how to identify data that may be displayed to mislead certain audiences.

(Explore): Students are given opportunities to view graphs individually, then partner up to discuss what observations each student made about the graphs on the reflective notes sheet.

(Explain): Teacher discusses with class what each group came up with and explains each part of the reflective notes to students (i.e. review of graphing terms, misleading graphs, and review of specific examples of graphs showing misleading information, or relevant information)

(Elaborate/Extend): Students will be asked to bring in a graph that they find complicated to read, misleading, or has information is overwhelming for audience to be discussed during next class.

Assessment (Evaluate): Teacher makes an informal pre-assessment on the student’s prior knowledge of graphing by observing student’s fill out their KWL charts independently. Teacher makes another informal assessment of students collaborating in groups and researching the given graphs on the reflective notes sheet. Lastly, teacher will assess the graphs the students bring in for the assigned homework during the next class.

Adaptations within the Inclusive Classroom: In this lesson, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the notes are mostly filled in, with a few questions the students are asked to answer in order to stay focused. Second, the directions to the assignment are given both verbally and written on the handout, as well as modeled to the class to accommodate many different learning styles. Lastly, pictures are given on the handouts of the notes for students to remind the students of the examples discussed in class in case the students need to refer back to the notes in the future.
## K-W-L Chart

**Topic:** GRAPHS

<table>
<thead>
<tr>
<th>What I Know</th>
<th>What I Want to Know</th>
<th>What I Learned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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Source: [http://whyspecial.com/tag/k-w-l-chart/](http://whyspecial.com/tag/k-w-l-chart/)
Global Warming – Day 3 Reflective Notes

Directions: Fill these notes out as we go over the topics in class…

1) Name the relationship between the coordinates, and explain what is occurring in each graph…

Graph #1: GPA

<table>
<thead>
<tr>
<th>Hours Studied</th>
<th>GPA</th>
</tr>
</thead>
</table>

Relationship: Direct Relationship
Description of what is occurring: 
*As hours studied increases, the GPA increases as well.*

Graph #2: Person’s Weight

<table>
<thead>
<tr>
<th># of Weeks Dieting &amp; Exercising</th>
<th>Person’s Weight</th>
</tr>
</thead>
</table>

Relationship: _________________
Description of what is occurring: 
______________________________

2) Graph a relationship between 2 variables (hint: think sports, health, academics, relationships, etc!). Be sure to have title of graph and both axis’ labeled appropriately.

<table>
<thead>
<tr>
<th>Relationship: _____________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is happening in the graph?</td>
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</tbody>
</table>
1) Which business is more profitable, based on the graphs above? Defend your answer.

2) Which business had greater rates of change in profit in the time period shown on the graphs? Defend your answer.
Global Warming – Day 3 Reflective Notes (cont’d)

Notes from class discussion on graph #2:

What is the graph below measuring?
The graph below is measuring global temperature change! It shows a major increase in the rate of change of temperature after the year 2000.

What is the graph below NOT measuring?
This graph is not measuring global temperature! There are more relevant graphs available to show the global temperatures throughout time!

What is the graph below measuring?
The graph below is measuring regional temperature change! It shows a major increase in the rate of change of temperature in the northern hemisphere after the year 2000.

What is the graph below NOT measuring?
This graph is not measuring global temperature change! The graph is only measuring regional temperature (Northern Hemisphere)...therefore; this graph is irrelevant for Global Warming!

http://earthobservatory.nasa.gov/Features/GISSTemperature/giss_temperature2.php
http://www.skepticalscience.com/medieval-warm-period.htm
Global Warming – Day 3 Reflective Notes (cont’d)

What is the graph below measuring?
The graph below is measuring global temperature change along with CO₂ concentration! It shows fluctuations in temperature over the course of time. A trend can be seen between CO₂ levels and global temperature on this graph.

What is the graph below NOT measuring?
This would not be a good graph to use to demonstrate rate of change in temperature over the course of history. There are better graphs out there to show such data!

Global Surface Temperature and Carbon Dioxide

Surface records show global average temperature continuing to rise during the last half century. Natural warming and cooling cycles (of several years to a decade) are also evident. Red (above average) and blue (below average) bars show global temperature compared to the average from 1901-2000.

Source: NOAA/NCD
c

********************** Key “Takeways” from today’s lesson……………………………………….***************

1) Choose the graph that best fits what specific information you are looking for, or what you are trying to determine.

2) Do not be fooled by misleading graphs…carefully examine ALL information on the graph to ensure you understand what the graph is showing.
DAY 4 - GLOBAL WARMING: PBL Introduction: Should actions be taken in response to the threat of global warming?

Lesson Objective(s): The learners will use prior and recently acquired knowledge of global warming to analyze debates in order to determine effective ways of communicating knowledge of global warming, determine valid evidence to support an argument, and the potential effects global warming could have on Earth to prepare for a team debate at the end of the unit plan.

Websites / Resources Used:
https://www.youtube.com/watch?v=gWT-EWKJR3M (Bill Nye vs. Marc Morano)
https://www.youtube.com/watch?v=AgZU5uvM5Ok (Bill Nye vs. Joe Bastardi)

Anticipatory Set: Teacher asks students to share graphs found from assigned homework. Sparks class discussion on evaluating different types of graphs. Students watch different debates referenced above in class. To keep students engaged, a sheet with questions guiding students on what they should be looking for during the debate is handed out.

Purpose: The purpose of this lesson is to teach students how to appropriately advocate for their beliefs on global warming through a debate format. In doing so, students will learn the importance of respecting each other’s beliefs, identifying valid information versus misc. information, presenting information in an organized and clear manner, and taking ownership of one’s own learning.

(Explore): Students will eventually be given opportunities to explore numerous resources (videos, data, notes, “time with teacher”, group members, etc) in order to come up with ideas for clear, concise, and engaging debate ideas to present their side of the argument “Should actions be taken in response to the threat of global warming?”

(Explain): Teacher facilitates a class discussion on debates watched in class and the accompanying guiding questions on the handout. Teacher and students reflect on a Q & A sessions with students to find and correct student misconceptions regarding the facts of global warming

(Elaborate/Extend): Students are assigned the PBL portion of this unit. See student handout labeled “Global Warming PBL Unit Intro”.

Assessment (Evaluate): Teacher makes an informal pre-assessment on the student’s discussion of graphs and how they interpreted them. Teacher makes another informal assessment during class discussion on the debates of global warming. Lastly, teacher will make a formal assessment on the students PBL debate at the end of the unit.

Adaptations within the Inclusive Classroom: Students are encouraged to take notes during discussion, however, a copy of student notes are given to students who have trouble taking notes and listening at the same time
Global Warming – Day 4 Debate Notes

Directions: Fill these notes out as we watch the following debates in class…

Video #1…Climate Realist Marc Morano Debates Bill Nye the Science Guy on Global Warming
https://www.youtube.com/watch?v=gWT-EWKIR3M

1) What is Marc Morano’s saying in his opening statement? Is this a valid statement?

2) What is wrong with Marc Morano’s example about the Medieval Warming Period (Bill Nye “calls him out” on this point)?

3) What is Bill Nye saying is the “main concern”?

4) As the facilitator mentioned, how will life on Earth be effected if Marc Morano is incorrect? What if Bill Nye’s argument is incorrect?

5) In your opinion, who won this debate? What was achieved?
6) What is Joe Bastardi saying in his opening statement? Is this a valid statement?

7) What is wrong with Joe Bastardi’s example about “this winter’s forecast” (2009-2010) (Bill Nye “calls him out” on this point)?

8) What are the reasons Joe Bastardi attributes to climate change, in this case, global warming?

9) Same as debate above, facilitator asks, what if Joe Bastardi is incorrect? What if Bill Nye’s argument is incorrect?

10) In your opinion, how does this debate end? Who won and why? What was achieved?
Global Warming – Day 4 Global Warming PBL Unit Intro

**TASK:** Each team of students will debate the issue on global warming: Should actions be taken in response to the threat of global warming?

**PURPOSE:** There comes a time when a decision needs to be made in order to move forward with a plan of action. This PBL assignment will allow students the opportunity to make up their own mind about global warming, defend their decision through collected research, and present a plan of action that needs to be done.

**PROCEDURE:** Teacher will assign each student to a team consisting of 5 to 6 students (there will be a total of 4 teams). Each team will work together for the next four days to research, collect, organize, and eventually present information on this controversial question to the class. To help each team stay on task, there will be a “guided schedule overview” as well as a more descriptive “task guideline” to follow each day to help each team work efficiently and meet all the requirements for this project. Task guidelines will be broken down into sub categories of *Required (must be complete), ^Recommended (students are encouraged to complete), and @Optional (if extra time prevails). In addition, each team member will have a specific job to do to ensure team success and help facilitate communication between team members. Teams may work ahead if granted permission by teacher.

**Key for Task Guidelines:**
- **Required** – indicated by * symbol. Students need to do these types of tasks.
- **Recommended** - indicated by ^ symbol. Students are encouraged to do these types of tasks.
- **Optional** - indicated by @ symbol. Students can choose to do these types of tasks if other tasks are complete.

**GRADING:**
1- See expectations on PBL rubric for grading information.
2- At the end of this project students will be asked to hand in...
   a. Reflection Questions and team notes in organized manner
   b. Final Presentation (if it something that is able to be turned in)
   c. Peer Evaluation grade
   d. Self-Reflection grade
GUIDED SCHEDULE OVERVIEW:

DAY 4 (Today):
1) Meet your assigned team members
2) Be present for introduction and Q&A session about this PBL assignment
3) Assign different job assignments to team members (see Task Guideline).
4) Review different methods of presentation formats and brainstorm other opportunities for presenting (see Task Guideline).
5) Begin filling out information on team checklist to ensure no steps are missed.

DAYS 5-6:
1) Complete any steps from previous day that were not completed yesterday
2) Follow the “Task Guideline” for Days 5 and 6.
3) Any students who need re-teaching on any materials please see teacher

DAY 7:
1) Complete any steps from previous day(s) that have not been completed
2) Follow the “Task Guideline” for Day 7.
3) Team members may choose to switch teams based on individual student beliefs.

DAYS 8-9:
1) Complete any steps from previous day(s) that have not been completed
2) Follow the “Task Guideline” for Days 8 and 9
3) Be 100% ready to present on Day 10.

DAY 10:
1) Team debates on global warming issue

DAY 11:
1) Reflect on project as a class
2) Fill out peer reviews and self-reflection grades
Global Warming – Task Guideline

TASK GUIDELINE

DAY 4:
*Assigning different roles for team members: Each student will have a different role/responsibility within the group. See roles/responsibilities on ‘PBL Job Assignments’ handout…

*Brainstorm possible presentation ideas: The list below contains ideas to get teams to start thinking of how they may want to present their argument. Teams may use any of the suggestions below or adapt the suggestions when necessary.

*Team checklist: Use this ‘PBL Checklist’ as a guide to keep your team on track and communicate with each other on the progress your team is making. Team will check off each line on each step when complete and the teacher will initial below each checkmark with approval so that the team may continue on to the next step.

DAYS 5-6:
*Fill out Venn diagram: Teams should fill out the Venn diagram on the handout entitled “Global Warming Venn Diagram” to ensure their understanding of Global Warming. If more space is needed, teams can create own Venn Diagrams or organize information using another method approved by teacher. Teams or individuals having a difficult time filling this out should see teacher as soon as possible for re-teaching of certain material.

*Find evidence: Teams will find evidence that supports the information written in the Venn diagrams, or help come up with new information to put in the Venn diagrams. Some helpful resources to get teams started on their search are found on the “Finding Evidence” sheet.

*Guiding questions: Teams should answer the ‘Guiding Questions’ from Days 5 & 6 research:

What are climate change feedback loops?: Investigate this question by understanding what a feedback loop is and how it pertains to climate change. Give examples to help explain this process.
Global Warming – Task Guideline

DAY 7:
* Team argument assigned: Teams will be assigned which side of the debate they are on by teacher at beginning of class.

*What should be done about global warming?: Teams need to research what can be done to reduce global warming, parties that may have vested interest in the debate of global warming, potential consequences of global warming. HINT…even if you believe nothing should be done and global warming is a hoax, you need to familiarize yourself with all sides of the issue so you may better defend your stance on the issue (the more prepared you are to answer questions, the better off you will be!)

*Guiding questions: Teams should answer the ‘Guiding Questions’ from Days 7 research:

@What types of people may want to influence the world’s perception on global warming?: For example, are there people, businesses, political officials, etc. that may have a vested interest ($$) in this subject other than the health of the planet? How would this help either side of the argument in a debate format (do both sides of the issue on global warming have specific agendas other than the health of our planet)? Explain.

@What efforts have been made worldwide to reduce the causes of global warming? Below are a few resources to help guide students on their search…

Websites:

Videos:
Kyoto Protocol - https://www.youtube.com/watch?v=xBMLOW3rwNQ
Kyoto Protocol - https://www.youtube.com/watch?v=QRIJnrD7wQ
Kyoto Protocol - https://www.youtube.com/watch?v=B1kASPfYxY
Emissions trading - https://www.youtube.com/watch?v=ReOj12UAus4
Global Warming – Task Guideline

DAYS 8-9:
* Student choice: Students are allowed to switch teams based on how strongly they feel about defending a certain side of this issue (based on availability…some students may have to play “devil’s advocate”).

* Collaborate on idea(s) for class debate: Teams need to come together to organize information, figure out methods to present information (see suggestions from Day 1), and consult rubric for expectations of each team’s debate. Teams should also be well prepared to answer questions and arguments from opposing teams.

* PBL rubric: View ‘PBL Rubric’ once again to ensure all aspects are being included in your debate project and that nothing is missing.

* PBL checklist: As a team, review and check off all items that need to be done in order to be 100% prepared for the class debate on sheet entitled ‘PBL Checklist’ if not already done so throughout project.

DAY 10:
* Debate Rules: A ‘talking stick’ will be used in order for one person to be completely heard before being interrupted by fellow classmates. Teacher is the facilitator of this debate and can give the ‘talking stick’ to anyone at his discretion. Each team will get no more than 5 minutes to present their case in a manner that was approved by the teacher, and each other team will get 2 minutes of rebuttal time to dispute the presenting team’s claims.

* Homework: Prior NYS Regents exam questions regarding global warming will be given as homework as another type of summative assessment for this project.

DAY 11:
* Group Peer Evaluation: A confidential group peer evaluation form will be handed out for all students to rate each other’s contribution to the group.

* Self Reflection: A confidential self-reflection form will be handed out to all students so they can evaluate themselves as a team member and how improvements can be made going forward.

* Class Reflection: Reflect on PBL project as a class during class discussion. Main ideas and essential questions will be reviewed based on how they were presented during debate. Teacher picks winning team of debate based on information presented, evidence used to back up claims, and clarity of argument presentation.
Global Warming – PBL Job Assignments

PBL JOB ASSIGNMENTS

1) **Time Keeper**: Is responsible for…
   - keeping team on task
   - giving reminders about time remaining in class and on project (reviewing schedule overview with team)
   - any other jobs/responsibilities team feels is appropriate

2) **Project Manager**: Is responsible for…
   - keeping team on task and ensuring all students know their roles/jobs
   - assigning student roles based on student ability and strengths
   - being a leader (not boss) to ensure team productivity
   - any other jobs/responsibilities team feels is appropriate

3) **Team Reporter**: Is responsible for…
   - recording information for team through notes, ideas, outlines, etc.
   - documenting any information team feels is valid
   - any other jobs/responsibilities team feels is appropriate

4) **Team Organizer**: Is responsible for…
   - Organizing all group materials
   - any other jobs/responsibilities team feels is appropriate

5) **Team ‘Toolbox’**: Is responsible for…
   - Any additional jobs that don’t fall under a specific category above (i.e. running errands, communicating to teacher concerns of group, etc)

6) **Team ‘Toolbox’**: Is responsible for…
   - Any additional jobs that don’t fall under a specific category above (i.e. running errands, communicating to teacher concerns of group, collaborating with other groups, etc.)
   - May have 2 of these positions if team consists of 6 students.

NOTE: Students will need to be flexible in adapting or taking on more responsibility than just the role he/she picks at the discretion of the team. For example, time keeper will also be responsible for contributing to team discussions, as well as making sure team is adhering to time schedule. All students are expected to contribute 100% effort to help each team work as effectively as possible.
Name: __________________  Date: ____________

Global Warming – PBL Debate Presentation Ideas

<table>
<thead>
<tr>
<th>GLOBAL WARMING TEAM DEBATE IDEAS</th>
<th>Global Warming is not a problem that constitutes action:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Warming is a problem that constitutes action:</td>
<td>• Create a timeline or series of graphs or charts that show the varying climates the world has experienced since the time of the dinosaurs.</td>
</tr>
<tr>
<td>• Conduct an experiment or make a scientific display illustrating the effects of greenhouse gases.</td>
<td>• Write a persuasive speech or letter to the editor that explains the need for further research into global climate changes.</td>
</tr>
<tr>
<td>• Create an advertising campaign to promote awareness of what causes global warming and what people can do to limit greenhouse gas emissions.</td>
<td>• Create a series of charts or graphs that illustrate costs related to enforcing global warming laws such as the Pavely Law or the Kyoto Protocol.</td>
</tr>
<tr>
<td>• Show graphs, charts, etc. displaying data supporting global temperatures in relation to CO₂ levels.</td>
<td>• Design a display that shows the cost of developing and using renewable energy sources (e.g., solar energy can be used in homes, but there is an initial cost of set-up, as well as backup plans needed when the sun isn’t shining).</td>
</tr>
<tr>
<td>• Write a fictional story or play illustrating the future effects of global climate change.</td>
<td>• Research current U.S. environmental policy and create a flyer explaining the Clear Skies Initiative and other strategies presented by President Bush that address global warming.</td>
</tr>
<tr>
<td>• Create a diorama or 3-D model of how your state or country might change as a result of global warming.</td>
<td>• Design a sign, poster, or brochure explaining the current Environmental Protection Agency plan for addressing global warming issues.</td>
</tr>
<tr>
<td>• Create a timeline or series of graphs or charts that show the varying climates the world has experienced since the time of the dinosaurs.</td>
<td>• Research what scientists who do not support conventional global warming theories say about changes in the earth’s climate and weather patterns and present these findings by creating a magazine-type story, a public service announcement, or a mini-documentary about your findings.</td>
</tr>
<tr>
<td>• Design a futuristic map of the world showing the effects of global climate change on the earth’s physical features, as well as on plant and animal life.</td>
<td>• Profile a renewable energy source and teach other students how it can be used (e.g., profile solar energy and how the average citizen can incorporate this into their everyday use). Create a display or working model of this energy source.</td>
</tr>
<tr>
<td>• Draw a food web showing how global climate changes affect the food chain/ecosystems.</td>
<td>• Research what scientists who support conventional global warming theories say about changes in the earth’s climate and weather patterns and present these findings by creating a magazine-type story, a public service announcement, or a mini-documentary about your findings.</td>
</tr>
<tr>
<td>• Create a map that shows the major countries that support the Kyoto Protocol. Develop hypotheses for how the U.S.’s refusal to participate in the treaty could affect foreign relations.</td>
<td>• Profile a renewable energy source and teach other students how it can be used (e.g., profile solar energy and how the average citizen can incorporate this into their everyday use). Create a display or working model of this energy source.</td>
</tr>
<tr>
<td>• Profile a renewable energy source and teach other students how it can be used (e.g., profile solar energy and how the average citizen can incorporate this into their everyday use). Create a display or working model of this energy source.</td>
<td>• Research what scientists who support conventional global warming theories say about changes in the earth’s climate and weather patterns and present these findings by creating a magazine-type story, a public service announcement, or a mini-documentary about your findings.</td>
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<tr>
<td>• Research what scientists who do not support conventional global warming theories say about changes in the earth’s climate and weather patterns and present these findings by creating a magazine-type story, a public service announcement, or a mini-documentary about your findings.</td>
<td>* Keep in mind; teams do not have to use the above ideas. Teams can modify ideas above or create own ideas for project debate. All debate ideas need to be approved by teacher before work can be done on them!</td>
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</tbody>
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53
*A more visual example of a debate project may look something like this picture below, with explanations for most, or all of the indicators listed…

Source: http://www.skepticalscience.com/graphics.php?g=8
Name: __________________   Date: __________

Global Warming – PBL Team Checklist

PBL CHECKLIST

Directions: Be sure teacher signs each step before moving on to the next step!

Team Name: ____________________ (ex. The Globonauts)

1) ___ Every team member has a job for this project.

________________________ - Time Keeper
________________________ - Project Manager
________________________ - Team Reporter
________________________ - Team Organizer
________________________ - Team Toolbox
________________________ - Team Toolbox

2) ___ Team has good understanding of PBL expectations, PBL rubric, and schedule of project.

3) ___ Team has read and discussed project ideas from ‘Global Warming Team Debate Ideas’ and discussed new ideas with teacher.

4) ___ Venn Diagram is completely filled out with teacher’s approval.

5) ___ Notes and ‘Guiding Questions’ are answered completely and accurately.

6) ___ ‘Guiding Questions’ and notes (if necessary) are answered for Days 5-6.

7) ___ Team is assigned (circle one) global warming…. BELIEVER DENIER

8) ___ ‘Guiding Questions’ and notes (if necessary) are answered for Day 7 completely and accurately.

9) ___ Team has re-visited ideas for team debate and discussed final presentation ideas with teacher.

10) ___ Team has re-visited PBL Rubric for expectations on debate.

11) ___ Team is 100% ready to debate!
Global Warming Venn Diagram

Directions: Answer the question below using the Venn Diagram to record what people on both sides of the global warming debate say about human responsibility for this issue. Be sure to note specific facts that support the different perspectives, and use the back of this paper to record more in-depth details as needed.

Question: Has human activity caused the world’s climate to change over the past 100 years?

<table>
<thead>
<tr>
<th>Those who say “yes” feel this way because:</th>
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<table>
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<th>Those who say “no” feel this way because:</th>
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<tr>
<th>Both sides agree that:</th>
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DAYS 5-9 - GLOBAL WARMING: Begin Research / Re-teaching Concepts

Lesson Objective(s): The learners will utilize various resources to take a stance on global warming by building upon their prior knowledge of the subject.

Websites / Resources Used:
See PBL handout from Day 4 lesson plan

Purpose: The purpose of this lesson is to teach students how to research relevant information to find valid evidence in supporting their stance on the issue of global warming. In doing so, students will take ownership of their own learning by reaching a conclusion on their own with only guidance to support them in their research.

(Explore): Students are given numerous resources (videos, data, notes, “time with teacher”, group members, etc) in order to come up with a strong debate idea to present their side of the argument “Should actions be taken in response to the threat of global warming?”

(Explain): Teacher briefly goes over all resources given to students in order to start them on their research journey of taking a stance on one side of this issue. Students will be placed on teams picked by the teacher based upon the skill sets of different students. Roles will be assigned to each student to ensure all students are participating and feel like part of the team (flexible grouping). Teams will not know what side of the argument they are on until the beginning of Day 6 of this unit. This is to ensure all students are understanding both sides of the issue. After Day 7, students will be offered (with no guarantees) to switch sides of the argument and join another team. Day 10 of this lesson will be presentations from each group in a class wide debate format (for the purpose of this example, it would hypothetically be 4 teams of 5 students per team). Day 11 will be time to reflect on our debate as a class.

(Elaborate/Extend): Students are given guidelines through their research to follow to keep them on track and freedom to pick and choose which research data makes the most sense to them to use in their argument regarding Global Warming.

Assessment (Evaluate): Teacher makes an informal assessments while helping teams conduct research, re-teach material to students who need extra help. Teacher periodically checks in with each team to see notes and ask questions about presentation ideas.

Adaptations within the Inclusive Classroom: In this lesson, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the teacher gives students who are struggling with concepts of global warming an opportunity for re-teaching of the material. Secondly, student roles are given to each student on each team based on student strengths. This ensures all students will feel comfortable contributing to the team. Lastly, resources are given in various different formats (videos, websites, articles, etc.) to help all students with varying learning styles understand this topic.
Finding Evidence

Websites:
- General information on global warming: http://www3.epa.gov/climatechange/kids/index.html
- General information on global warming: http://www.carbonify.com/articles/climate-change-global-warming.htm
- General information on global warming: https://www.ncdc.noaa.gov/monitoring-references/faq/global-warming.php
- Impacts of climate change: http://www.climatehotmap.org/index.html

Videos:
- Global Warming Believers - https://www.youtube.com/watch?v=dkR3TI6xyzU
- Global Warming Believers - https://www.youtube.com/watch?v=ue9Rin38dDw
- Global Warming Believers - https://www.youtube.com/watch?v=Vxygt5zZBe4
- Global Warming Believers - https://www.youtube.com/watch?v=KJhbQIIu4mk
- Global Warming Deniers - https://www.youtube.com/watch?v=ap6YfQx9I64
- Global Warming Deniers - https://www.youtube.com/watch?v=C35pasCr6KI

Data & Graphs:
- Use the following google searches to begin looking for this information...
  - Global temperatures of history of earth
  - CO₂ emissions vs. global temperature change
  - Global warming graphs

Other important research tips:
- Be sure to research other factors causing global temperatures to change, other than greenhouse gases!
GUIDING QUESTIONS (DAYS 5-6)

1. What is the difference between climate change and global warming?

2. What are some causes of global warming (according to scientists that believe in it)?

3. What are the causes of climate change?

4. What are the major greenhouse gases?

5. How do greenhouse gases affect the Earth’s atmosphere?
GUIDING QUESTIONS (DAY 7)

1. What effects does global warming have on life on Earth and are these effects problematic?

2. Can global warming be prevented or minimized? Why or Why not?

3. How can global warming be prevented or minimized?
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<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
<td>The information appears to be disorganized or missing.</td>
<td>Information is organized, but missing some notes/ guided questions from certain days.</td>
<td>Information is organized with with most of the required material turned in.</td>
<td>Information is very organized and easy to follow along and understand.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Teamwork</strong></td>
<td>No communication is observed between team members.</td>
<td>Little communication between team members is observed and evidence is representative of this in final project.</td>
<td>Team works well together for majority of project. Some instances of miscommunication between team members are observed and is evidenced by final project.</td>
<td>All team members collaborate effectively and final project is representative of the effective communication between all team members.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Quality of Information</strong></td>
<td>Information has little or nothing to do with the main topic.</td>
<td>Information clearly relates to the main topic. No details and/or examples are given.</td>
<td>Information clearly relates to the main topic. It provides 1-2 pieces of evidence to support claims.</td>
<td>Information clearly relates to the main topic. It includes several supporting details and/or examples to support claims.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Effort</strong></td>
<td>Little or no effort is shown from team for duration of project.</td>
<td>Effort is variable from team for duration of project.</td>
<td>Effort is shown for majority of project from team for duration of project.</td>
<td>100% team effort is given through the duration of this project.</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Debate</strong></td>
<td>Team refuses to debate or contributes nothing to the quality of the debate.</td>
<td>Team gives more opinions than facts during debate. Team is unprepared for opportunities given for rebuttals.</td>
<td>Team provides quality information with evidence to back up claims. Rebuttals are answered, but show gaps in knowledge of both sides of the issue.</td>
<td>Team provides quality information with evidence to back up claims. Rebuttals are well-answered, showing adequate knowledge of both sides of the issue.</td>
<td></td>
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</tr>
</tbody>
</table>
**DAY 10 - GLOBAL WARMING: Team Debate**

**Lesson Objective(s):** The learners will debate current issues of global warming to promote a better understanding of the topic.

**Websites / Resources Used:**
Resources used at student’s discretion

**Purpose:** The purpose of this lesson is to teach students how to appropriately advocate for their beliefs on global warming through a debate format. In doing so, students will learn the importance of respecting each other’s beliefs, identifying valid information versus misc. information, presenting information in an organized and clear manner, and taking ownership of one’s own learning.

(Explore): Students are given directions for the debate and will present their ideas in various formats.

(Explain): Students will explain their side of the debate through their presentations.

(Elaborate/Extend): Teams are given opportunities for rebuttals in which they can expose weaknesses in other team’s side of the argument.

**Assessment (Evaluate):** Teacher will be facilitator of the debate and assess students presentations as well as their process throughout the project from the ‘PBL rubric’.

**Adaptations within the Inclusive Classroom:** All teams are given time to practice their presentations so that speaking roles can be assigned to all students on the team. This ensures all students will feel comfortable contributing to the team and not feel pressured to answer questions unless they volunteer to do so. Lastly, many different project ideas were given to students to choose from that incorporated many different styles of learning.
Global Warming – Regents Questions

HOMEWORK

Directions: Answer the following questions with the most appropriate answer from what you have learned during this PBL assignment. The questions are not in order because they were taken straight off old Earth Science Regents examinations!

26 Which diagram best represents how greenhouse gases in our atmosphere trap heat energy?

![Diagram of greenhouse gases and heat energy]

50 Which ocean current has the greatest warming influence on the climate of the Outer Banks of North Carolina?
(1) Gulf Stream Current  
(2) North Atlantic Current  
(3) Labrador Current  
(4) Canary Current

83 Describe one way the volcanic ash cloud may have contributed to cooler weather conditions in Europe. [1]

8 The ozone layer protects life on Earth by absorbing harmful ultraviolet radiation. The ozone layer is located between 17 kilometers and 35 kilometers above Earth’s surface in which atmospheric temperature zone?
(1) troposphere  
(2) stratosphere  
(3) mesosphere  
(4) thermosphere

51 Describe the effect that global warming most likely will have on both present-day glaciers and sea level.
8 Which event is inferred to have contributed to the significant global climate change that may have caused the mass extinctions of organisms at the end of the Late Cretaceous Epoch? 

(1) the Big Bang 
(2) an asteroid impact 
(3) formation of Pangaea 
(4) shifting of Earth’s magnetic poles

42 Compared to non-El Niño years, which climatic conditions exist near the equator on the western and eastern sides of the Pacific Ocean during an El Niño event? 

(1) The western Pacific is drier and the eastern Pacific is wetter. 
(2) The western Pacific is wetter and the eastern Pacific is drier. 
(3) The western and the eastern Pacific are both wetter. 
(4) The western and the eastern Pacific are both drier.

17 Which process is responsible for the greatest loss of energy from Earth's surface into space on a clear night? 

(1) condensation 
(2) conduction 
(3) radiation 
(4) convection

44 During an El Niño year, winter climatic conditions in New York State will most likely be 

(1) colder and wetter 
(2) colder and drier 
(3) warmer and wetter 
(4) warmer and drier
15 Which event followed a massive volcanic eruption and led to the cooling of global temperatures?
(1) thunderstorms that developed near the eruption
(2) the release of carbon dioxide and methane gases
(3) the outflow of magma over Earth's surface
(4) the addition of ash particles into the atmosphere

17 Which event is inferred by most scientists to be responsible for a climate change that has recently led to a decrease in the size of most glaciers?
(1) a decrease in the rate of divergence of lithospheric plates along a mid-ocean ridge
(2) a decrease in the amount of insolation reaching Earth's surface
(3) an increase in the amount of greenhouse gases in Earth's atmosphere
(4) an increase in the amount of vegetative cover in the tropics

38 How did the huge ash cloud that covered Alaska in 1989 affect the amount of insolation reaching Earth's surface and the air temperatures near Earth's surface?
(1) Insolation decreased and temperatures increased.
(2) Insolation increased and temperatures decreased.
(3) Both insolation and temperatures increased.
(4) Both insolation and temperatures decreased.

50 The inferred position of the future coastline is based on the assumption that the
(1) total amount of global precipitation will decrease
(2) thickness of the ozone layer will decrease
(3) concentration of carbon dioxide in Earth's atmosphere will increase
(4) rate of uplift of the North American continent will increase

85 State one advantage of using solar energy instead of burning fossil fuels to produce thermal energy for your home. [1]
DAY 11 - GLOBAL WARMING: PBL Reflection

Lesson Objective(s): The learners will reflect on the process of the project and what they learned by reviewing the essential questions of the unit.

Websites / Resources Used: None

Purpose: The purpose of this lesson is for all students to understand the main ideas from the unit. Both teacher and student feedback can be utilized for future creations of PBL projects and personal feedback and reflection. Students are also given the opportunity to prepare themselves to pass the regents exam by seeing questions regarding global warming for homework.

(Explore): Students reflect on their learning over the course of this project.

(Explain): Teacher is sure to cover the main ideas and essential questions of this unit so that no students leave with any misconceptions. Teacher encourages students to see that an overwhelming number of scientific experts conclude that global warming is occurring and actions need to be taken.

(Elaborate/Extend): Students are given another type of format to show their learning from this project in answering regents style questions taken from past exams.

Assessment (Evaluate): Teacher makes an informal assessment during class reflection. Teacher makes formal assessments grading regents based questions students turned in for homework.

Adaptations within the Inclusive Classroom: Students are given multiple measures of assessment (self, peer, team, teacher) so that a good indicator for the participation of each team member can be established. Teacher can use student’s IEP’s and knowledge of each student to grade individuals based on a sliding scale in terms of each student’s capabilities.
**Global Warming – PBL Group Peer Evaluation**

**PBL Project Group Peer Evaluation Form (Confidential)**

**Your Name**

___________________________________________

**Group Name/Number**

___________________________________________

**Period:** __________

**Problem Assignment**

___________________________________________

Carefully evaluate the performance of each member of your group, **excluding yourself**, over the period of the group project.

<table>
<thead>
<tr>
<th>1. Did his/her fair share of the work that was required</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Cooperated with other group members</td>
</tr>
<tr>
<td>3. Shared responsibilities and did not try to take charge inappropriately</td>
</tr>
<tr>
<td>4. Completed his/her share of the work on schedule</td>
</tr>
<tr>
<td>5. Always submitted his/her best effort</td>
</tr>
<tr>
<td>6. Communicated thoughts and feelings effectively</td>
</tr>
<tr>
<td>7. Was always well prepared for meetings and the actual presentation.</td>
</tr>
<tr>
<td>8. Participated in, and contributed to, all relevant discussions</td>
</tr>
<tr>
<td>9. Attended group meetings when required to do so.</td>
</tr>
<tr>
<td>10. I would choose this person, over all others, to be in the same group with me in the future.</td>
</tr>
</tbody>
</table>

**Group Member #1 Name:**

**Group Member #2 Name:**

**Group Member #3 Name:**

**Group Member #4 Name:**

The average for this person (1 to 5): ___________ ___________ ___________

(Round average for each group member to two decimal places, e.g. 4.25)

**Use the back of this form for any additional comments you would like to make.**

Global Warming – PBL Self Evaluation

SELF REFLECTION GRADE

TEAM NAME: ____________________________
GROUP MEMBERS: _______________________________________________________

Please rate your contribution to the group and evaluate the group on a scale from 1 – 5 with 5 being the highest.

INDIVIDUAL EVALUATION: Name ________________________________

__1. Following teacher’s instructions
__2. Asking meaningful questions
__3. Contributing ideas and information
__4. Helping the group stay on task
__5. Contributing materials

I could improve on _______________________________________________________

I rank my contributions to the group as _______ because ____________________________.

GROUP EVALUATION:

__6. Asking for help when needed
__7. Sharing responsibilities
__8. Respecting others
__9. Explaining things to others
__10. Doing things on time

I rank our group’s efforts at working together as _____ because ____________________________

PBL UNIT #2: THE CARBON CHALLENGE

• Grade level: 9th Grade Earth Science

• Topic/Case Study: Carbon Footprint: The Carbon Challenge

• Time Period: 9-10 Days, 45 minute class periods

• Teacher Rationale:

  This PBL unit plan will engage students to educate themselves and become more aware of how their everyday actions may affect the environment. As with PBL Unit #1, this unit plan encourages the students to be active learners, with the teacher transitioning from an instructor in the first couple days of the unit, to a facilitator during the PBL project. This unit plan not only gives meaning to the importance of learning about carbon emissions by connecting it to student’s everyday lives, but it also puts the emphasis on students being active learners by working toward a solution. After each student is taught the ‘basic’ information of a carbon footprint to begin the project, the teacher gives students the freedom to take control of their project by only providing the students with guidance when necessary to expand upon their knowledge of a carbon footprint.

  The intent of this PBL project is that students will improve their problem-solving abilities by working together as a team and utilizing all available resources to them. In this regard, it is an authentic project as it is preparing students for life after high school in which they will experience similar assignments. Teamwork, leadership, communication, and organizational skills will also be pivotal for students to learn and practice as they proceed through this unit. The unit plan is built similar to PBL Unit #1 in an effort to achieve some consistency so the students can feel comfort in knowing a little bit about the procedures due to having done one PBL unit already. Because PBL is a new way of learning for many students, this comfort level is meant to lessen the anxiety many students may have going into a project as “open-ended” as this one. It is important to note here that students will also be assessed on their knowledge of the carbon footprint based off past regents questions pertaining to this topic in order to prepare students for the regents exam. This is a key component to this unit because many learners may struggle with being assessed differently from the way in which the content was learned (multiple choice questions versus inquiry based learning). The teacher should remind learners that they are learning science in this unit to become more educated citizens as opposed to just passing an exam; however the exam is just a means to an assessment indicating whether learning took place.

  Lastly, the unit is built for all learners to progress at different paces. Re-teaching is available for students who require it, as well as additional assignments and research activities to build upon knowledge of the essential questions for students who move at a faster pace. Therefore, the PBL unit is intended for all learners to be successful in learning the scientific standards as well as the skills mentioned above.

• Overview:

  This unit aims at increasing student awareness and understanding of the carbon footprint associated with different activities by humans. Students will begin the unit with instruction from the teacher to provide basic information on the definition of a carbon footprint, as well as major sources and major sinks associated with carbon dioxide. After students demonstrate adequate
knowledge of these main ideas, the ideas will be reinforced and built upon by participating in the PBL project. Students will be grouped in teams according to their class period, and then broken down even further into different groups within these teams. Each team’s task is to provide a proposal in reducing the team’s total carbon footprint (calculated in class with a carbon footprint calculator) by the highest percentage.

Over the course of this unit, students will utilize many different resources, including both hard and soft scaffolds to educate themselves on what constitutes a carbon footprint and what factors increase or decrease carbon footprints. The knowledge the students gained will be on display in a team presentation to the teacher on ideas to limit the team’s total carbon footprint, as well as many other assessments of students throughout the unit.

The goal of this PBL unit plan is to provide sufficient scaffolds for learners that need additional support, as well as providing additional resources for students who understand the big ideas quickly and want to learn more about this topic through further research. Therefore, by the end of the unit, all students will understand the big ideas of the unit, and some students will have learned even more about the implications of these big ideas.

- **Next Generation Science Standards:**
  HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.
  HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
  HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

- **Big Ideas**
  6. Decisions made by humans have environmental consequences on our planet for better or worse.
  7. Small changes in behavior can add up to result in massive changes for environment.
  8. Create change through education, by example, and being an advocate for change.

- **Essential Content Questions:**
  3. What is a carbon footprint?
  4. What are sources and sinks of carbon dioxide and what are some examples of each?
  5. What types of activities lead to a larger carbon footprint? A smaller carbon footprint?
  6. Why should humans be concerned about our carbon footprint?
  7. How can we minimize our carbon footprint?

- **Hard Scaffolds implemented:**
  Graphic Organizers
  Models
  Writing to Learn
  Reflective Notes
  Main Ideas from Guided Questions
  Frayer Model - Vocabulary
  Driving Question
Additionally Assigned Work
Videos/Pictures

• **Soft Scaffolds implemented:**
  Direct Instruction
  Organizational Aides (Job Responsibility, Guided Schedule, Task Guideline)
  Re-Teaching
  Specific Feedback
  Flexible Grouping
  Reflective Questioning*
  Extended Time*
  Hurdle Help*
  Peer Teaching*

*See ‘Teacher Recommendations for Implementation’ for an explanation of these soft scaffolding techniques.

• **Recommendations for teacher implementation:**
  Along with the many hard scaffolds that can be seen in this lesson, there are also many soft scaffolding techniques that teacher’s should be aware of during implementation. First, it is important to build student’s confidence during the first couple days of this unit by providing learners with a solid understanding of key vocabulary terms and essential questions. This can be witnessed in the first few days of this unit in forms of direct instruction, class discussion, and re-teaching. Once the PBL portion of this project begins, students are then supported by the teacher with specific feedback, hurdle help, and reflective questions that build off the student’s prior knowledge attained from the first few days of this unit. All of these soft scaffolding techniques differ with each teacher and student. It is essential the teacher is aware of all student’s learning styles and personalities to keep each student engaged in the project while providing just enough information to keep the student progressing forward as an active learner.

  Because communication and organization are such key pieces to the success of this project, it is important that the teacher aides each group with organization tips (if needed) as well as help open communication lines between students that will help this project run much smoother. Additionally, because group work is such a key piece to this project, it is expected that peer teaching will naturally occur between students with academically stronger students working with academically weaker students within the same team.

  Lastly, as with all PBL projects, it is important to adjust the time for this unit as necessary. Extended time may be warranted if students need more time for research, communicate, planning and/or organizing the final presentation. Teacher will assess the day to day productivity of teams and make a decision about the timeline for this project. A day after the presentations should be left open for student reflection of the PBL unit that will provide valuable input for both the student and teacher.
### Unit Plan Outline:

**9-DAY UNIT CALENDAR**

**9th Grade Level (45 minute periods)**

**PBL Unit: Carbon Footprint Challenge**

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1:</strong> WHAT IS A 'CARBON FOOTPRINT'?</td>
<td><strong>Day 2:</strong> RESEARCHING MAJOR CONTRIBUTING FACTORS OF A CARBON FOOTPRINT</td>
<td><strong>Day 3:</strong> INTRODUCTION TO PBL ASSIGNMENT... CARBON CHALLENGE</td>
</tr>
<tr>
<td>- Carbon Footprint Introduction (10 min)</td>
<td>- Warmup Quiz (5 min)</td>
<td>- Carbon Footprint Q&amp;A Sheet (10 min)</td>
</tr>
<tr>
<td>- Reflective Notes (10 min)</td>
<td>- Concept Maps - Guided search on major contributing factors to carbon footprint (25 min)</td>
<td>- Introduce PBL Assignment (20 min)</td>
</tr>
<tr>
<td>- Video (10 min)</td>
<td>- Presentations (15 min)</td>
<td>- Students begin first few steps of assignment (15 min)</td>
</tr>
<tr>
<td>- Ticket out Door (10 min)</td>
<td></td>
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</tr>
<tr>
<td><strong>Day 5:</strong> GROUP WORK / RETEACHING</td>
<td><strong>Day 6:</strong> GROUP WORK / RETEACHING</td>
<td><strong>Day 7:</strong> GROUP WORK</td>
</tr>
<tr>
<td>- Students continue working on activities indicated on Task Guideline sheet (45 min)</td>
<td>- Students continue working on activities indicated on Task Guideline sheet (45 min)</td>
<td>- Students continue working on activities indicated on Task Guideline sheet (45 min)</td>
</tr>
<tr>
<td>- Re-teaching available from teacher for students who need it</td>
<td>- Re-teaching available from teacher for students who need it</td>
<td></td>
</tr>
<tr>
<td><strong>Day 9:</strong> REFLECTION ON PBL ACTIVITY</td>
<td></td>
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<tr>
<td>- Teams fill out assessments of project (10 min)</td>
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</tr>
<tr>
<td>- Class Reflection on PBL project (20 min)</td>
<td></td>
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</tr>
<tr>
<td>- Teacher reviews hmwk on past regents questions with students (15 min)</td>
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</tbody>
</table>
• Unit plans

Day 1 through 9

DAY 1 – CARBON CHALLENGE: Can greenhouse gas emissions be controlled (specifically CO₂)?

Lesson Objective(s): The learners will create T-charts to identify examples of carbon sources and sinks as well as the differences between the two.

New Vocabulary Words:
Carbon Footprint Carbon Sink
Carbon Source

Websites / Resources Used:
Video URL’s are included below in lesson plan breakdown

Anticipatory Set: Students are asked to discuss with a partner their definition of a carbon footprint and their ideas of what constitutes a carbon footprint.

Purpose: The purpose of this lesson is to teach students the methods in which carbon dioxide is released into the atmosphere, as well as methods in which it is absorbed so that they can understand efforts made to control carbon dioxide emissions. Students will use this information as a foundation of knowledge for future life decisions.

(Explore): Students will discuss as a class what they feel comprises a carbon footprint. Teacher will lead discussion so that student’s misconceptions regarding this topic are answered and a clear representation of a carbon footprint is demonstrated through the ‘Day 1 Reflective Notes’.

(Explain): Students watch short videos below explaining main ideas of a carbon footprint.
https://www.youtube.com/watch?v=8q7_aV8eLUE

(Elaborate/Extend): This part of the lesson plan will be set up today with the video and class discussion, but will mostly take place tomorrow when the students investigate each major phase of the carbon footprint in more detail.
https://www.youtube.com/watch?v=AGRIo87oAUg

Assessment (Evaluate): Teacher makes an informal pre-assessment on the student’s prior knowledge of the carbon footprint during class discussion. A more formative assessment is made when students are asked to hand in there T-charts of sources and sinks for carbon dioxide.

Adaptations within the Inclusive Classroom: This lesson is designed for multi-sensory learners who learn by instruction given in many different formats. This lesson contains partner discussions, large group discussions, videos, pictures, copy of notes, and a graphic organizer in the form of a T-chart. This lesson provides the foundation of the next couple weeks in this unit, so it is imperative all students have a good knowledge base on the term carbon footprint and the associated sources and sinks of carbon.
Vocabulary:

**Pictures:**

Definition; the amount of carbon dioxide and other carbon compounds emitted due to the consumption of fossil fuels by a particular person, group, etc.

http://aboutboulder.com/blog/learners-guide-to-evaluating-your-carbon-footprint/

**Example:**

<table>
<thead>
<tr>
<th>Housing</th>
<th>Travel</th>
<th>Food</th>
<th>Products</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.05</td>
<td>0.95</td>
<td>1.11</td>
<td>0.52</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Total: 4.0 t CO2e/capita

Note: Based on the average global footprint per capita in carbon dioxide equivalents. Figure excludes capital, government, and land-use change emissions. In 2010 the average personal footprint is estimated to be about 5.0 t CO2e/capita.

Source: Hutson & Peter 2009, WRI

**Non-Example / Notes:**

The carbon footprint is *not an actual footprint*, but is compared to a footprint because they are both something you leave behind as you go!

**Pictures:**

Definition: Processes or regions that predominately produce atmospheric carbon dioxide

*Tip:* Source = starting point

**Carbon Source**

**Example(s):**

- Burning of fossil fuels/forests
- Decomposition
- Respiration (Animals breathing)
- Weathering of carbonate rocks

**Non-Example / Notes:**

Carbon Sinks are the opposite…storing carbon!
### Carbon Sink

**Definition:** Processes or regions that predominately absorb atmospheric carbon dioxide

*Tip:* sink = storage

<table>
<thead>
<tr>
<th>Example(s):</th>
<th>Non-Example / Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photosynthesis</td>
<td>Carbon sources are the opposite… producing CO₂</td>
</tr>
<tr>
<td>Oceans</td>
<td></td>
</tr>
</tbody>
</table>

### Reflection Questions (ticket out the door):

1. In your own words, what is a carbon footprint?

2. What are sources and sinks of carbon dioxide and what are some examples of each?
During our discussion of carbon footprints, fill in the following terms from the word bank.

**Word Bank:**
- Photosynthesis
- Oceans
- Weathering of carbonate rocks
- Respiration
- Decomposition
- Burning fossil fuels*
- Forest Fires

*Fossil Fuels = Coal, Oil, & Natural Gas

<table>
<thead>
<tr>
<th>CO₂ Sources</th>
<th>CO₂ Sinks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you missed any key parts of the discussion, or would like further information, use the URL below for more information…

**DAY 2 – CARBON CHALLENGE: Researching major contributing factors of a carbon footprint**

**Lesson Objective(s):** The learners will use guided research to find information on the major categories influencing a carbon footprint.

**New Vocabulary Words:**

None

**Websites / Resources Used:**

Video URL’s are included below in lesson plan breakdown

**Anticipatory Set:** Students are given a warmup quiz to answer two essential questions in this unit that were covered during yesterday’s lesson.

**Purpose:** The purpose of this activity is for students to demonstrate a deeper understanding of how water, transportation, waste, and electricity all factor into a carbon footprint. This information will be vital in every day decision making, as well as on the PBL project introduced tomorrow.

**(Explore):** Students explore each major factor contributing to a carbon footprint in teams through a guided search (see ‘Concept Mapping’ worksheet attached to lesson).

**(Explain):** Teams present what they came up with to class as teacher fills in any essential information that was missed in presentation as necessary.

**(Elaborate/Extend):** Students will build off this knowledge during PBL project assigned tomorrow.

**Assessment (Evaluate):** Teacher assesses quizzes from students, as well as team presentations informally.

**Adaptations within the Inclusive Classroom:** In this lesson, students are grouped in to predetermined teams to utilize all students’ strengths. See job assignments in “Day 2 Job Assignments” sheet attached to lesson. Students feeling anxious to present will have adequate time to practice or will be able to contribute to team in other ways, as determined by teacher and student.
Name: ___________________  Date: ____________
Carbon Footprint – Day 2 Job Assignments

Role Card # 1
Facilitator:
Makes certain that everyone contributes and keeps the group on task.

Role Card # 2
Recorder:
Keeps notes on important thoughts expressed in the group. Writes final summary.

Role Card # 3
Reporter:
Shares summary of group with large group. Speaks for the group, not just a personal view.

Role Card # 4
Materials Manager:
Picks up, distributes, collects, turns in, or puts away materials. Manages materials in the group during group work.

Role Card # 5
Time Keeper:
Keeps track of time and reminds groups how much time is left.

Role Card # 6
Checker:
Checks for accuracy and clarity of thinking during discussions. May also check written work and keeps track of group points scores.
Carbon Footprint – Day 2 Concept Mapping

Directions: Many factors contribute to the calculation of a carbon footprint. In assigned teams, please research one of the major factors below associated with a carbon footprint (first come, first serve). Use your research to fill out the graphic organizer below (or create your own). There is a website and video listed next to your topic to help you get started on your research, but feel free to just use these as ‘starters’ and branch out to other resources from there!

Carbon Footprint Factors (Choose one):

1) WATER USAGE –
   Website: http://www.rivernetwork.org/sites/default/files/Toolkit_Emissions2-8-12.pdf
   Video: https://www.youtube.com/watch?v=zNdbj3PbX6o

2) TRANSPORTATION –
   Website: http://www3.epa.gov/climatechange/ghgemissions/sources/transportation.html
   Video: https://www.youtube.com/watch?v=Heqd7lH7ZTA

3) WASTE (TRASH) –
   Video: https://www.youtube.com/watch?v=IoCVrkcaH6Q

4) ELECTRICITY –
   Website: http://electronics.howstuffworks.com/how-to-tech/how-to-reduce-technology-carbon-footprint.htm
   Video: https://www.youtube.com/watch?v=3tD4mp6QwEk

Name: ___________________ Date: ____________
Carbon Footprint: ex) Water Usage

1) How does it contribute to Carbon Footprint?
2) Specific Examples?
3) Who are the major ‘offenders’?
4) Solution(s)?
**DAY 3 - CARBON CHALLENGE: What is your carbon footprint?**

**Lesson Objective(s):** The learners will discover how their household is contributing to the carbon footprint through the use of a carbon footprint calculator.

**Websites / Resources Used:**
http://www3.epa.gov/carbon-footprint-calculator/

**Anticipatory Set:** Students are asked to answer all of the questions they know the answer to on the ‘Carbon Footprint Q&A’ sheet attached to this lesson.

**Purpose:** The purpose of this lesson is for students to be aware of their carbon footprint. In addition, students will see the profound effect that small lifestyle changes can have when they are carried out through a community.

**(Explore):** Students are asked to take home the ‘Carbon Footprint Q&A’ sheet to find out the answers they left blank by any research means necessary (ask parents, siblings, web, etc.).

**(Explain):** Teacher makes point for students to self-reflect on how much they knew about their household carbon footprint by looking at how many answers the students left blank. Teacher introduces expectations of PBL project for this unit (see ‘Carbon Challenge PBL Unit Intro’). Teams are assigned with roles for each team member (see ‘Carbon Challenge PBL Job Assignments’).

**(Elaborate/Extend):** Students will be taking their answers from the ‘Carbon Footprint Q&A’ sheet and inputting them into the carbon footprint calculator to find out their household carbon footprint in tomorrow’s lesson.

**Assessment (Evaluate):** Students assess themselves on how much they know about the daily activities that create their carbon footprint.

**Adaptations within the Inclusive Classroom:** In this lesson, students work individually on questions that are personal to their homes and lifestyle, generating individual interest in the assignment. Having students work individually on this assignment promotes confidence in the student. This, coupled with the fact that students will bring the assignment home should relieve some anxiety stemming from trying to get it complete before the period ends.
Name: ___________________  Date: ____________
Carbon Challenge – Day 3 Carbon Challenge Q&A

HOME ENERGY

1) What is your household's primary heating source? ______________________

2) Enter your average monthly bill or other data for each source of energy your household uses…
   Natural Gas _____  Propane _____  Oil _____  Electricity _____

3) What is the average temperature your thermostat is set at in the summer?  ______

4) What is the average temperature your thermostat is set at in the winter?  ______

5) Do you wash your clothes under cold water in washing machine?  ______

6) Do you use a drying rack or dryer to dry clothes?  ______

7) Are any of the following rated as EnergyStar?
   a. Refrigerator _____  
   b. Windows _____  
   c. Furnace/Boiler _____

TRANSPORTATION

8) How many vehicles does your household own (and use regularly)?  ______

9) Who performs maintenance on these vehicles? ______________________

10) What is the average miles per week put on each vehicle and miles per gallon of each vehicle?
    a. Vehicle #1 _____ mi/wk  _____ mpg
    b. Vehicle #2 _____ mi/wk  _____ mpg
    c. Vehicle #3 _____ mi/wk  _____ mpg
    d. Vehicle #4 _____ mi/wk  _____ mpg

WASTE

11) Do you recycle at your house?  ______ (if yes, circle all items recycled below)
    a. Aluminum/steel cans
    b. Plastic
    c. Glass
    d. Newspaper
    e. Magazines
**Task:** Which team (class period) can reduce their total carbon footprint by the highest percentage?

**Purpose:** As responsible citizens to our planet, we need to be aware of how our actions are affecting the environment around us to ensure future generations have the same environmental resources we have enjoyed. In terms of carbon footprint, there are things we can control (driving vs. walking), and things we cannot control (breathing). This project will give us an opportunity to see how we can make better everyday decisions to limit our negative impacts on the atmosphere, as well as brainstorm possible ideas to further reduce such negative impacts.

**Procedure:** Each class period will comprise a separate team competing against each other. Within each team, will be separate groups of students working on specific items for their team (see ‘PBL Groups’ sheet). Each team will work together for the next five days to research, collect, organize, and eventually present information on how they plan to reduce their carbon footprint by the percentage indicated by the team. To help each team stay on task, there will be a “guided schedule overview” as well as a more descriptive “task guideline” for each group to follow to help each team work efficiently and meet all the requirements for this project. Task Guidelines will be broken down into sub categories of *Required (must be complete), ^Recommended (students are encouraged to complete), and @Optional (if extra time prevails). Teams may work ahead if granted permission by teacher, but each step needs to be signed off by teacher to ensure the team is on track.

**Key for Task Guidelines:**
*Required – indicated by * symbol. Students need to do these types of tasks.
^Recommended - indicated by ^ symbol. Students are encouraged to do these types of tasks.
@Optional - indicated by @ symbol. Students can choose to do these types of tasks if other tasks are complete.

**Grading:**
3- See expectations on PBL rubric for grading information.
4- At the end of this project students will be asked to hand in...
   a. Final Presentation of Carbon Footprint Reduction (including percentage of reduced carbon emissions, method(s) of reducing carbon output, all students individualized carbon footprints, notes, research, math calculations, etc. in an organized manner).
   b. Peer Evaluation grade
   c. Self-Reflection grade
GUIDED SCHEDULE OVERVIEW:

DAY 3 (Today):
1) Introduction to PBL assignment
2) Complete as much as possible on Carbon Q&A Challenge sheet (take home for homework to complete)
3) Assign students to groups within their team (See ‘PBL Groups’ sheet).
4) Begin filling out information on ‘PBL Checklist’ to ensure no steps are missed.

DAY 4:
1) Complete any steps from previous day that were not completed on Day 3.
2) Finish individual household carbon footprint using completed homework assignment (Carbon Challenge Q&A). Individualized printouts for each student will need to be turned in at end of project.
3) Follow group specific ‘Task Guideline’ to ensure all phases of project are complete
4) Any students who need re-teaching on any materials please see teacher

DAYS 5-6:
1) Complete any steps from previous day(s) that have not been completed
2) Follow group specific ‘Task Guideline’.

DAY 7:
1) Groups come together as team to work on final presentation
2) Check ‘PBL Checklist’ to ensure all steps are complete and PBL project is ready to be presented and turned in tomorrow

DAY 8:
1) Team presents ideas and turns in carbon reduction proposal to teacher
2) Homework: Regents test questions on carbon footprint

DAY 9:
1) Reflect on project as a class
2) Fill out peer reviews and self-reflection grades
PBL Groups (within each team)

7) **Project Managers**: 4-5 students responsible for…
   - keeping each group on task and on schedule
   - ensuring all students know their role and are contributing to team
   - assigning student roles based on student ability and strengths
   - being a leader (not boss) to ensure team productivity
   - any other jobs/responsibilities team feels is appropriate

8) **Mathematicians**: 4-5 students responsible for…
   - keeping track of carbon emissions for teams (adding all individual household carbon footprints, subtracting carbon emissions based on changes in behaviors,
   - showing all work performed so teacher can follow math easily
   - any other jobs/responsibilities team feels is appropriate to reach goal

9) **Engineers**: 4-5 students responsible for…
   - Researching/brainstorming ideas on how to reduce carbon footprint (not mentioned in carbon footprint calculator)
   - Designing additional ways to reduce carbon footprints (at home, school, or work (individually or as a class))
   - any other jobs/responsibilities team feels is appropriate

10) **Reporters**: 3-4 students responsible for…
    - Reporting majority of information to teacher during presentation
    - Students in this role need to be knowledgeable of what all groups are doing in order to present accurate information
    - any other jobs/responsibilities team feels is appropriate

11) **Managers**: 4-5 students responsible for…
    - Ensuring all groups have organized work which can be compiled into one big presentation toward end in an efficient manner
    - Suggest ideas to make the organization easier and more efficient
    - any other jobs/responsibilities team feels is appropriate

**NOTE**: Students will need to be flexible in adapting or taking on more responsibility than just a singular role if needed, at the discretion of the team. For example, a mathematician may also need to be responsible for contributing to team discussions that the team reporters are having to keep everyone connected. All students are expected to contribute 100% effort to help each team work as effectively as possible.
DAYS 4-7 - CARBON CHALLENGE: Carbon Challenge PBL Project

Lesson Objective(s): The learners will apply teamwork skills in various aspects to learn multiple strategies in reducing one’s carbon footprint.

Websites / Resources Used:
See PBL Project handouts

Anticipatory Set: Students are asked to finish all of the questions on their Carbon Footprint calculator that they found the answer to on the ‘Carbon Footprint Q&A’ sheet that was assigned for homework.

Purpose: The purpose of this PBL assignment is for students to work together in various aspects to solve a problem (reducing the team’s carbon footprint). This assignment represents an authentic problem where various components need to be completed in order to move on to the next step. Communication, organization, time management, and research skills are all necessary in order to complete this project in the allotted time frame.

(Explore): Students are asked to follow their group’s ‘Task Guideline’ to explore and research an aspect of the assignment. Groups will work together through each step of the ‘Task Guideline’ to learn about their specific phase of the project.

(Explain): Students will then need to coordinate with other groups to explain their portion of the project and how they came up with their solutions (peer teaching). Teacher intervenes when necessary as a facilitator of hard and soft scaffolds.

(Elaborate/Extend): Students will then be asked to present their findings to the teacher to explain their total percentage of carbon reduction and possible ways to make these reductions feasible.

Assessment (Evaluate): Students will be assessed informally on their ability to work together throughout the project. They will also be assessed formatively on their ‘Guiding Questions’ and ‘Task Guidelines’ assignments, as well as their final presentation, according to the ‘PBL Rubric’.

Adaptations within the Inclusive Classroom: In this PBL project, students are assigned (with input) to roles within their teams based upon their strengths. Each group assignment varies in terms of difficulty, so that all students can participate in the success of the team. In addition, there are also ‘re-teaching days’ built into the first few days of this project, where struggling students may get an opportunity for additional direct instruction.
Carbon Challenge – PBL Team Checklist

PBL CHECKLIST

**Directions:** Be sure teacher signs each step before moving on to the next step!

Class Period: _____
Team Name: ____________________ (ex. The Carbonators)

12) ____ Team has good understanding of PBL expectations, PBL rubric, and schedule of project.

13) ____ Every student is assigned to a group for this project.

__________, ____________, ____________, ____________ - Project Managers

__________, ____________, ____________, ____________ - Mathematicians

__________, ____________, ____________, ____________ - Engineers

__________, ____________, ____________, ____________ - Reporters

__________, ____________, ____________, ____________ - Managers

14) ____ All team members have completed and printed out individual household Carbon Footprint

15) ____ All required steps are complete on each group’s ‘Task Guideline’

16) ____ (#1-5) ‘Guiding Questions’ are answered completely and accurately.

17) ____ (#6-8) Group specific ‘Guiding Questions’ are answered completely and accurately (if time permitted).

18) ____ All reporters and other groups have communicated effectively with each other on how the information will be presented to teacher.

19) ____ All materials are organized in a way that makes presentation clear and effective

20) ____ Team has an official percentage of carbon reduction that can be justified with a plan for such reduction.

21) ____ Groups/Individuals have completed recommended and/or optional activities (if time permitted).

22) ____ Team has re-visited PBL Rubric for expectations on presentation.

23) ____ Team is 100% ready to present!
**PROJECT MANAGER’S (PM’s) - TASK GUIDELINE**

**Team members:** Ensure each student is comfortable with role in group. *Hint: every student has a strength…make use of it in your project!

**Divide up project manager’s (PM’s) tasks:** Divide tasks up for each PM (for example, perhaps one PM is assigned for each team, such as a PM for the mathematicians, a PM for the engineers, a PM for the reporters, and a PM for the managers).

**Ensure all individual carbon footprints are complete:** All students must have completed and printed a carbon footprint value. See example provided on ‘Teacher Carbon Footprint’ sheet.

**PBL checklist:** Use this ‘PBL Checklist’ as a guide to keep your team on track and communicate with each other on the progress your team is making. Team will check off each line on each step when complete and the teacher will initial below each checkmark with approval so that the team may continue on to the next step.

**PBL rubric:** View ‘PBL Rubric’ once again to ensure all aspects are being included in your debate project and that nothing is missing. Review rubric with all group or team members to ensure everyone understands expectations.

**Communication:** Ensure all communication between groups and team members is clear.

**Efficiency:** Ensure team and all groups are working in an efficient manner. If not, re-direct team members to make most of their time.

**Guiding Questions (#1-5):** Answer as a group ‘Guiding Questions’ sheet.

**PM’s Guiding Questions (#6-8):** Answer as a group ‘PM’S Guiding Questions’ sheet.

@In the year 6015…: It is the year 6015, humans have been extinct for thousands of years. Your task as a scientist is to find out the cause of the extinction (must be related to carbon emissions, global warming). As a scientist, you need to provide your theory with evidence to support it. *(Hint: use methods we use today to find out about Earth’s past history!)*
**Carbon Challenge – Mathematician’s Task Guideline**

**MATHEMATICIAN’S - TASK GUIDELINE**

*Calculations: Calculate the following…

- **Team Total Carbon Footprint:**
- **Team Total Carbon Footprint after Individual Planned Actions:**
- **Team Total Carbon after Team Planned Actions:**
- **Average of Individual Carbon Footprint:**
- **School Total of Household Carbon Footprints:**

*See teacher for carbon reduction value (lbs.) associated with team ideas to reduce carbon:*

Reporters on team will research a carbon reduction value in lbs. for each idea to lower the carbon emissions for the team.

*Present Data: A minimum of 3 graphs (of any type) must be developed to present the data in a way that is clear, organized, and easily presentable. *Hint: Take time in deciding which information you would like to include on your graphs!*

*Guiding Questions (#1-5): Answer as a group ‘Guiding Questions’ sheet.

^Mathematician’s Guiding Questions (#6-8): Answer as a group ‘Mathematician’s Guiding Questions’ sheet.

@ Forecast Interpolation: Research world population trends over the years. Using your research on world population and carbon footprints, create a graph that forecasts what global emissions will look like in the future (10, 100, 1,000 years from now).
ENGINEER’S - TASK GUIDELINE

*Review & Research: Review and research common sources and sinks for carbon dioxide on our planet. With these in mind, brainstorm ideas on what could be done to limit carbon emissions into the atmosphere.

*Implementation: Follow up on the team’s best ideas with ways to implement the idea into common practice. For instance, how does your team propose to integrate your ideas into the way of life of a person, workplace, community, household, etc.? What resources will you need to design and implement your idea? What “roadblocks” will you face along the way? *Hint: Focus your thinking on one specific major source or sink of carbon dioxide as opposed to looking at solving the entire carbon footprint!

*Guiding Questions (#1-5): Answer as a group ‘Guiding Questions’ sheet.

~Engineer’s Guiding Questions (#6-8): Answer as a group ‘Engineer’s Guiding Questions’ sheet.

@ Alternative Energy Sources: Pick one or more alternative energy solutions and evaluate its effectiveness based on the reduction of carbon footprint, cost to implement, and feasibility. Be sure to include all other facts that one would want to consider before committing to the alternative energy source.
REPORTER’S - TASK GUIDELINE

*Research: Research values of carbon dioxide (lbs.) that are associated with reduction by implementing specific activities (i.e. walking rather than driving a truck 20 miles week = carbon reduction of 125 lbs. of CO₂). Reporters need to work closely with engineers by finding out which ideas are being implemented to reduce carbon footprint because a value of carbon dioxide reduction (lbs.) needs to be associated when these ideas in order to determine the total percentage of a team’s reduction in carbon footprint. Reporters also need to work closely with mathematicians to figure out conversions and values of reduction after implementing carbon reduction ideas. Here is a few websites that will help…
http://www.carbonify.com/carbon-calculator.htm
http://waterfootprint.org/en/

*Communication: Communicate with group about decisions made and reasons behind decision-making. Familiarity with group’s design and implementation process is essential when presenting project.

*Guiding Questions (#1-5): Answer as a group ‘Guiding Questions’ sheet.


@ Reach out to Community: What are some ways we could share this information with the community? Provide a sample or model that could help educate community members on carbon footprints.
Carbon Challenge – Manager’s Task Guideline

**MANAGER’S - TASK GUIDELINE**

*Organization Duties:* All group work is organized in a folder, binder, computer, or other specific place that can be easily stored and retrieved when necessary.

*Check & Double Check:* Group work is checked every day for accuracy at end of class and collected in a way that work can be easily continued next class.

*Misc.:* All other duties required of team for project, including, but not limited to helping other groups, facilitating communication between groups, note taking, “odds & ends”, etc.

^Manager’s Guiding Questions (#6-8): Answer as a group ‘Manager’s Guiding Questions’ sheet.

@Production Video: Create an educational video about carbon emissions. Possible ideas include…Interviewing teachers, custodians, maintenance staff, administrators, parents, etc. in order to identify the most wasteful aspects of their day-to-day routine in terms of carbon emissions (personal or professional). Finding ‘interesting facts’ about carbon footprints and present them in ways that can be considered “eye opening” to viewers. See example below…
https://www.youtube.com/watch?v=FlhnDvb7Exo
https://www.youtube.com/watch?v=gTS2Yp-Ugl0
Your Household Carbon Footprint Report

⚠️ Make a selection in all calculator sections and fields to improve your results.

Your Current Total: 72,907
New Total After Your Planned Actions: 70,622
U.S. Average: 65,010

Your Planned Actions Are Equal to:
- Saving 116 gallons of gas
- Planting 26 trees
- Recycling 736 tons of waste

Let friends know what you’re doing to reduce CO₂ emissions
Share It!

Small Actions Add Up

If 100 of your friends took these actions, over 5 years their households would avoid 1,142,307 pounds of emissions, equivalent to the emissions from burning 58,280 gallons of gasoline.
<table>
<thead>
<tr>
<th>If you take all of the new actions you’ve selected:</th>
<th>Dollar Savings</th>
<th>CO₂ Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn down heating thermostat on winter nights by 3°</td>
<td>$189</td>
<td>951 lbs.</td>
</tr>
<tr>
<td>Turn up A/C thermostat in summer by 2°</td>
<td>$20</td>
<td>93 lbs.</td>
</tr>
<tr>
<td>Enable the power management features on your computer</td>
<td>$13</td>
<td>59 lbs.</td>
</tr>
<tr>
<td>Reduce the number of miles you drive on Vehicle 1</td>
<td>$102</td>
<td>574 lbs.</td>
</tr>
<tr>
<td>Replace Vehicle 1 with one that gets MPG</td>
<td>$0</td>
<td>0 lbs.</td>
</tr>
<tr>
<td>Reduce the number of miles you drive on Vehicle 3</td>
<td>$102</td>
<td>608 lbs.</td>
</tr>
<tr>
<td>Replace Vehicle 3 with one that gets MPG</td>
<td>$0</td>
<td>0 lbs.</td>
</tr>
<tr>
<td><strong>Your Estimated Totals:</strong></td>
<td><strong>$426</strong></td>
<td><strong>2,285 lbs.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By taking all of the actions you are already doing:</th>
<th>Dollar Savings</th>
<th>CO₂ Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use clothes line or drying rack instead of dryer for 50% of your laundry</td>
<td>$46</td>
<td>211 lbs.</td>
</tr>
<tr>
<td>Replace your refrigerator with ENERGY STAR models</td>
<td>$38</td>
<td>177 lbs.</td>
</tr>
<tr>
<td>Recycling: newspapers, glass, plastic, aluminum and steel cans, magazines</td>
<td>$0</td>
<td>1,164 lbs.</td>
</tr>
<tr>
<td><strong>Your Estimated Totals:</strong></td>
<td><strong>$84</strong></td>
<td><strong>1,551 lbs.</strong></td>
</tr>
</tbody>
</table>
GUIDING QUESTIONS

1. What is a carbon footprint?

2. What are sources and sinks of carbon dioxide and what are some examples of each?

3. What types of activities lead to a larger carbon footprint? A smaller carbon footprint?

4. How can we minimize our carbon footprint?

5. Why should humans be concerned about our carbon footprint?
PROJECT MANAGER'S GUIDING QUESTIONS

In questions 6-8...make predictions as to what will happen to the human race in the future.

6. Will humans become extinct? Why or why not? Will carbon emissions have anything to do with such extinction? Why or why not?

7. How long will humans remain a species on Earth? Will humans adapt and turn into another species to avoid extinction? Explain your reasoning!

8. Assuming humans are gone, what do you think will happen to carbon dioxide levels? Support your theories with research!
6. How much do carbon offsets cost? (See PM’s for what carbon offsets are, or see URL here)… http://legendpower.com/power-conservation/what-are-carbon-offsets/

7. How much money would your team need to offset your carbon footprint completely?

8. Compute the following for your team...
   - **Average Individual Household Gallons of gas saved:**
   - **Average Individual Household Trees planted:**
   - **Average Individual Household Tons of Waste Recycled:**
   - **Team Total Gallons of gas saved:**
   - **Team Total Trees planted:**
   - **Team Total Tons of Waste Recycled:**
   - **School Total Gallons of gas saved:**
   - **School Total Trees planted:**
   - **School Total Tons of Waste Recycled:**

What can you conclude off of these numbers?
ENGINEER’S GUIDING QUESTIONS

6. What is climate engineering?

7. What types of design proposals have already been completed or are in the working process stage to offset carbon emissions? What have been the most and least successful design proposals to offset carbon emissions?

8. Identify 2 specific designs that have been proposed to offset carbon emissions and list the pros and cons of both designs (i.e. T-chart).
REPORTER’S GUIDING QUESTIONS

6. What are carbon offsets?
   [http://legendpower.com/power-conservation/what-are-carbon-offsets/]

7. Can we place a money value on carbon emissions? Explore this question with your own research and then state your opinion!

8. Are carbon offsets a good thing or bad thing? Explain both sides through the use of a T-chart.
6. How has politics intervened with science in terms of carbon footprints (think national)? Give specific examples.

7. In what ways could we ‘police’ carbon footprints by monitoring carbon emissions on a personal or organizational level?

8. Do you believe carbon emissions should be monitored by government authorities with consequences for exceeding limits? Why or why not?
DAY 8 - CARBON CHALLENGE: Carbon Challenge PBL Project Presentation

Lesson Objective(s): The learners will apply presentation skills to demonstrate knowledge of reducing one’s carbon footprint by explaining their research in their own words.

Websites / Resources Used:
See PBL Project handouts

Anticipatory Set: None

Purpose: Presentation skills are extremely important in many professions. Students will need to develop this skill through practice. Simplifying complex information so that it can be understood by all is very challenging, and requires significant knowledge of the material being presented.

(Explore): Already done during PBL research phase.

(Explain): Teams will present proposal to teacher according to expectations given on ‘PBL Intro’ and ‘PBL Rubric’.

(Elaborate/Extend): After presenting, students will be given rest of class and assigned for homework Regents questions based on carbon footprints in order to assess their knowledge in a different format to ensure knowledge of the content.

Assessment (Evaluate): Students will be assessed on their presentation according to ‘PBL Rubric’. Students will also be assessed on the ‘Regents Questions’ they answer for homework.

Adaptations within the Inclusive Classroom: In this PBL project, students are assigned (with input) to roles within their teams based upon their strengths. Presentation speakers will be given adequate time to formulate what they will present. Struggling students will be prepped beforehand on questions they might be asked from teacher to give them adequate time to process question and an answer.
## PBL Rubric: Carbon Challenge

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
<td>The information appears to be disorganized or missing.</td>
<td>Information is organized, but missing some notes/ guided questions from certain days.</td>
<td>Information is organized with most of the required material turned in.</td>
<td>Information is very organized and easy to follow along and understand.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teamwork</strong></td>
<td>No communication is observed between team or group members.</td>
<td>Little communication between group members is observed and evidence is representative of this in final project.</td>
<td>Groups work well together for majority of project. Some instances of miscommunication between groups are observed and is evidenced by final project.</td>
<td>All team and group members collaborate effectively and final project is representative of the effective communication between all team members.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality of Information</strong></td>
<td>Information has little or nothing to do with the main topic.</td>
<td>Information clearly relates to the main topic. No details and/or examples are given.</td>
<td>Information clearly relates to the assigned task. It provides 1-2 pieces of evidence to support claims.</td>
<td>Information clearly relates to the assigned task. It includes several supporting details and/or examples to support claims.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Effort</strong></td>
<td>Little or no effort is shown from team for duration of project.</td>
<td>Effort is variable from team for duration of project.</td>
<td>Effort is shown for majority of project from team for duration of project.</td>
<td>100% team effort is given through the duration of this project.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Proposal</strong></td>
<td>Team refuses to make carbon reduction proposal</td>
<td>Team only provides carbon reduction plan based on carbon footprint calculator with no additional proposals/ideas presented.</td>
<td>Team provides quality information with evidence to support carbon reduction plan. Gaps in plan of carbon reduction proposal or knowledge are exposed during proposal presentation.</td>
<td>Team provides quality information with evidence to back up proposal ideas. Adequate knowledge of essential questions is displayed by presenters.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HOMEWORK

Directions: Answer the following questions with the most appropriate answer from what you have learned during this PBL assignment. The questions are not in order because they were taken straight off old Earth Science Regents examinations!

50 The inferred position of the future coastline is based on the assumption that the
   (1) total amount of global precipitation will decrease
   (2) thickness of the ozone layer will decrease
   (3) concentration of carbon dioxide in Earth’s atmosphere will increase
   (4) rate of uplift of the North American continent will increase

11 Evidence supports the idea that increases in carbon
dioxide and methane in Earth’s atmosphere are
major contributors to global warming. This is
based primarily on the fact that carbon dioxide
and methane are excellent absorbers of
   (1) gamma rays           (3) visible light
   (2) microwaves          (4) infrared radiation

85 State one advantage of using solar energy instead of burning fossil fuels to produce thermal energy for your
   home. [i]

12 Global warming is most likely occurring due to
   an increase in
   (1) carbon dioxide and methane gases in the atmosphere
   (2) oxygen and nitrogen gases in the atmosphere
   (3) ultraviolet radiation and x rays reflected from Earth
   (4) visible light and radio waves reflected from Earth
27 The graph below shows changes in carbon dioxide concentrations in Earth's atmosphere over a 140-year period. Carbon dioxide concentrations are shown in parts per million (ppm).

![Atmospheric CO2 Levels](image)

This significant change in CO₂ concentration is most likely caused by:

1. decreased cloud cover, and is predicted to decrease average global temperatures
2. decreased volcanic activity, and is predicted to increase average global temperatures
3. increased use of fossil fuels, and is predicted to increase average global temperatures
4. increased El Niño activity, and is predicted to decrease average global temperatures

17 Which event is inferred by most scientists to be responsible for a climate change that has recently led to a decrease in the size of most glaciers?

1. a decrease in the rate of divergence of lithospheric plates along a mid-ocean ridge
2. a decrease in the amount of insolation reaching Earth's surface
3. an increase in the amount of greenhouse gases in Earth's atmosphere
4. an increase in the amount of vegetative cover in the tropics
DAY 9 - CARBON CHALLANGE: Carbon Challenge PBL Reflection

Lesson Objective(s): The learners will reflect on their learning of the carbon footprint and be able to apply this knowledge in various formats (everyday life, tests, interviews, etc.).

Websites / Resources Used:
None

Anticipatory Set: Students will fill out Peer and Self assessments based on their contributions to the PBL project.

Purpose: It is important to reflect on the process of the PBL project, as well as to reinforce the essential questions so students do not move forward building upon or creating any misconceptions.

(Explore): Students explore other and discuss other teams’ potential ideas and critique them based on feasibility, costs, practicality, etc.

(Explain): Teacher awards team winner and gives justification on the selection.

(Elaborate/Extend): None.

Assessment (Evaluate): Students will be assessed on their presentations according to ‘PBL Rubric’, ‘Peer Evaluation’ and a ‘Self-Reflection’ rating.

Adaptations within the Inclusive Classroom: The format for this lesson is confidential assessments, followed by a class discussion of the PBL activities. All student feedback is welcomed by teacher to improve upon and adapt for future use.
Name: __________________                Date: ___________

Carbon Challenge – PBL Group Peer Evaluation

**PBL Project Group Peer Evaluation Form (Confidential)**

**Your Name**
______________________________________________________

**Group** (Circle one)  PM  Mathematician  Engineer  Reporter  Manager

**Period:** __________

**Problem Assignment**
______________________________________________________

Carefully evaluate the performance of each member of your group, excluding yourself, over the period of the group project.

5 – Outstanding  4 – Good  3 – Satisfactory  2 – Poor  1 – Unacceptable

<table>
<thead>
<tr>
<th></th>
<th>Group Member #1 Name:</th>
<th>Group Member #2 Name:</th>
<th>Group Member #3 Name:</th>
<th>Group Member #4 Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Did his/her fair share of the work that was required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Cooperated with other group members</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3.</td>
<td>Shared responsibilities and did not try to take charge inappropriately</td>
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<tr>
<td>4.</td>
<td>Completed his/her share of the work on schedule</td>
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<td></td>
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<tr>
<td>5.</td>
<td>Always submitted his/her best effort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Communicated thoughts and feelings effectively</td>
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<td></td>
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<tr>
<td>7.</td>
<td>Was always well prepared for meetings and the actual presentation.</td>
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<tr>
<td>8.</td>
<td>Participated in, and contributed to, all relevant discussions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Attended group meetings when required to do so.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>I would choose this person, over all others, to be in the same group with me in the future.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average for this person (1 to 5): ___________     ___________     ___________     ___________     ___________

(Round average for each group member to two decimal places, e.g. 4.25)

Use the back of this form for any additional comments you would like to make.

SELF REFLECTION GRADE

TEAM NAME:___________________

GROUP MEMBERS:________________________________

Please rate your contribution to the group and evaluate the group on a scale from 1 – 5 with 5 being the highest.

INDIVIDUAL EVALUATION:

Name_______________________________

____1. Following teacher’s instructions
____2. Asking meaningful questions
____3. Contributing ideas and information
____4. Helping the group stay on task
____5. Contributing materials
____6. Asking for help when needed
____7. Sharing responsibilities
____8. Respecting others
____9. Explaining things to others
____10. Doing things on time

I could improve on________________________________________________________

I rank my contributions to the group as__________because________________________

GROUP EVALUATION:

____1. Following teacher’s instructions
____2. Asking meaningful questions
____3. Contributing ideas and information
____4. Staying on task and meeting deadlines
____5. Sharing responsibilities
____6. Respecting others
____7. Explaining things to others
____8. Solving problems within the group
____9. Consistent effort
____10. Producing a quality product

I rank our group’s efforts at working together as_____because_____________________

PBL UNIT #3: WATER – OUR MOST PRECIOUS RESOURCE

- **Grade level:** 9th Grade Earth Science

- **Topic/Case Study:** Water: Our Most Precious Resource

- **Time Period:** 12-14 Days, 45 minute class periods

- **Teacher Rationale:**

  This PBL unit plan focuses on a multi-disciplinary approach to engage and motivate students to educate themselves and become more aware of the current water crisis the planet is facing. As with the earlier PBL Units, this unit plan is student-centered and encourages the students to be active learners, with the teacher transitioning from an instructor in the first couple days of the unit, to a facilitator during the PBL project. Many students who struggle with PBL projects are those that do not have sufficient enough background knowledge on the topic to be successful with the teacher only acting as a facilitator. Therefore, direct instruction is provided at the beginning of this unit to give all students the opportunity to create a foundation of knowledge of which to build from. This puts all learners at a similar starting place to begin the PBL unit, and expand upon their existing knowledge.

  This unit plan will engage students by not only by giving meaning to the importance of learning about water and connecting it to student’s everyday lives, but it also puts the emphasis on students being active learners by working toward a solution through modeling, researching, discussion, and writing to learn. After each student is taught the ‘basic’ background information of water that is necessary to begin the PBL project, the teacher gives students the freedom to take control of their project by only providing the students with guidance when necessary to expand upon their knowledge of how important water is to life, and steps that need to be taken to ensure it is available to all people of the world.

  The intent of this PBL project is that students will improve their problem-solving abilities by working together as a team and utilizing all available resources available to them. In this regard, it is an authentic project as it is preparing students for life after high school in which they will experience similar assignments. Teamwork, leadership, communication, and organizational skills will also be pivotal for students to learn and practice as they proceed through this unit. Students will be asked to work towards solving an extremely complex and relevant ‘real-world problem’ by breaking the task down into more manageable parts and designating specific work to utilize each student’s strengths. The unit plan is built similar to the previous PBL units in an effort to achieve some consistency so the students can feel comfort in knowing a little bit about the procedures due to having successfully completing a PBL unit already. Because PBL is a new way of learning for many students, this comfort level is meant to lessen the anxiety many students may have going into a project as “open-ended” as this one. In addition to the hands-on, research-based, team oriented portion of the PBL activities, students will also be assessed on answering past regents questions pertaining to this topic in order to prepare students for the regents exam. This is a key summative component to this unit because many learners may struggle with being assessed differently from the way in which the content was learned (multiple choice questions versus inquiry based learning). The teacher should remind learners that they are learning science in this unit to become more educated citizens as
opposed to just passing an exam; however the exam is just a means to an assessment indicating whether learning took place.

Lastly, the unit is built for all learners who progress at different paces. Re-teaching and more guided instruction is available for students who require it, as well as additional assignments and research activities to build upon knowledge of the essential questions for students who move at a faster pace and need less scaffolding. Therefore, the PBL unit is intended for all learners to be successful in learning the scientific standards as well as the skills mentioned above for students to become college and career ready.

• Overview:

The intention of this unit is to make students aware of the water crisis the planet is currently experiencing. It is important students understand the severity of this crisis, why it is happening, and what can be done (at different levels) to combat this crisis. Students will begin the unit with instruction from the teacher to provide basic background information regarding water, such as the water cycle, where water is stored, how it can be extracted, factors that affect the availability of water. After students demonstrate adequate knowledge of these main ideas through a writing project of their choice, the ideas will be reinforced and built upon by participating in the PBL project. Students will be grouped in teams that accentuate each student’s strengths and asked to investigate possible solutions to ending the water crisis at different levels (individual, local, and global). Each team’s task is to provide a proposal in a format of their choosing to promote ideas at these different levels that may help remedy the water crisis.

Over the course of this unit, students will utilize many different resources, including both hard and soft scaffolds to educate themselves on what constitutes a water crisis and steps that need to be taken to ensure safe water for everyone. The knowledge the students gained will be on display in a team presentation on ideas to ensure that everyone has an available source of clean water by promoting ideas that can be accomplished at an individual, local, and global level.

The goal of this PBL unit plan is to provide sufficient scaffolds for learners that need additional support, as well as providing additional resources for students who understand the big ideas quickly and want to learn more about this topic through further research. Therefore, by the end of the unit, all students will understand the big ideas of the unit, and some students will have learned even more about the implications of these big ideas and perhaps even how to apply them realistically.

• Next Generation Science Standards:

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
• **Big Ideas**
  1. Decisions made by humans have environmental consequences on our planet for better or worse.
  2. People can take for granted natural resources that have always been readily available.
  3. Water is a renewable natural resource, in a limited quantity. (The term “renewable” resource does not imply that it is unlimited.)
  4. Water is essential for life.

• **Essential Content Questions:**
  1. What is the hydrologic cycle?
  2. What are all of the processes involved in the hydrological cycle?
  3. What makes water such a valuable resource?
  4. What is a closed loop system?
  5. What is a ‘water crisis’?
  6. How much of the water on Earth is accessible for human use?

• **Hard Scaffolds implemented:**
  Graphic Organizers
  Models
  Writing to Learn
  Reflective Notes
  Main Ideas from Guided Questions
  Driving Question
  Additionally Assigned Work
  Videos/Pictures

• **Soft Scaffolds implemented:**
  Direct Instruction
  Organizational Aides (Job Responsibility, Guided Schedule, Task Guideline)
  Re-Teaching
  Specific Feedback
  Flexible Grouping
  Reflective Questioning*
  Extended Time*
  Hurdle Help*
  Peer Teaching*

*See ‘Teacher Recommendations for Implementation’ for an explanation of these soft scaffolding techniques.

• **Recommendations for teacher implementation:**
  Along with the many hard scaffolds that can be seen in this lesson, there are also many soft scaffolding techniques that teacher’s should be aware of during implementation. First, it is important to build student’s confidence during the first couple days of this unit by providing learners with a solid understanding of key vocabulary terms and essential questions. This can be
witnessed in the first few days of this unit in forms of direct instruction, class discussion, and re-teaching. Once the PBL portion of this project begins, students are then supported by the teacher with specific feedback, hurdle help, and reflective questions that build off the student’s prior knowledge attained from the first five days of this unit. All of these soft scaffolding techniques differ with each teacher and student. It is essential the teacher is aware of all student’s learning styles and personalities to keep each student engaged in the project while providing just enough information to keep the student progressing forward as an active learner.

Because communication and organization are such key pieces to the success of this project, it is important that the teacher aides each group with organization tips (if needed) as well as help open communication lines between students that will help this project run much smoother. Additionally, because group work is such a key piece to this project, it is expected that peer teaching will naturally occur between students with academically stronger students working with academically weaker students within the same team.

Lastly, as with all PBL projects, it is important to adjust the time for this unit as necessary. Extended time may be warranted if students need more time for research, communicate, planning and/or organizing the final presentation. Teacher will assess the day to day productivity of teams and make a decision about the timeline for this project. A day after the presentations should be left open for student reflection of the PBL unit that will provide valuable input for both the student and teacher.

- Unit plan outline:

**12-DAY UNIT CALENDER**

9th Grade Level (45 minute periods)
Water: Our Most Precious Resource

<table>
<thead>
<tr>
<th>DAY 1: WHERE DOES WATER COME FROM?</th>
<th>DAY 2: WATER CYCLE (cont'd)</th>
<th>DAY 3: GROUNDWATER CHARACTERISTICS</th>
<th>DAY 4: AQUIFER MODELS</th>
<th>DAY 5: WATER BUDGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Pre-Assessment (10 min)</td>
<td>● Review of Water Cycle through Animated Water Cycle Websites (20 min)</td>
<td>● Students predict porosity and permeability (5 min)</td>
<td>● Aquifer Intro (10 min)</td>
<td>● You-Tube (3 min)</td>
</tr>
<tr>
<td>● Intro to Unit (25 min)</td>
<td>● Reflection on Water Crisis (25 min)</td>
<td>● Students are asked to write a procedure to determine permeability and porosity (20 min)</td>
<td>● Aquifer Models (20min)</td>
<td>● Predictions</td>
</tr>
<tr>
<td>- Importance of Water &amp; Water Cycle</td>
<td>● Cleanup (5 min)</td>
<td>● Reflection questions (10 min)</td>
<td>● Presentations (5 min)</td>
<td>● Introduce Water Budget (15 min)</td>
</tr>
<tr>
<td>● Introduce Writing to Learn Activity (10 min)</td>
<td>● Reflection (10 minutes)</td>
<td>● Closure (5 min)</td>
<td>● Students work on Reflection sheet questions (5 minutes)</td>
<td>● Water Budget Guided Instruction (10 min)</td>
</tr>
</tbody>
</table>

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DAY 6: “THINK INDIVIDUALLY, LOCALLY, AND GLOBALLY” PBL PROJECT
- Teacher introduces PBL project (15 min)
- Students get in groups, delegate jobs, gameplan for project (15 min)
- Begin working on Task Guideline (15 min)

DAY 7: PBL WORK DAY
- Each team works on activities outlined in the Task Guideline breakdown (45 min)

DAY 8: PBL WORK DAY
- Each team works on activities outlined in the Task Guideline breakdown (45 min)

DAY 9: PBL WORK DAY
- Each team works on activities outlined in the Task Guideline breakdown (45 min)

DAY 10: PBL WORK DAY
- Each team works on activities outlined in the Task Guideline breakdown (45 min)

DAY 11: PBL PRESENTATION
- Each team presents project ideas (30 min)
- Each student works on Regents style questions (15 min)

DAY 12: PBL REFLECTION
- Review classwork/hmwk (30 min)
- PBL Reflection Discussions (15 min)

Unit plans
Day 1 through 9

DAY 1- WATER: The Importance of Water and the Hydrologic Cycle

Lesson Objective(s):
1) The learners will apply communication skills along with prior knowledge to be able to identify and explain the process of the hydrologic cycle.

2) The learners will apply reasoning skills to be able to identify the problem referred to as the Earth’s water crisis.

New Vocabulary Words:
- Precipitation
- Condensation
- Sublimation
- Capillary Action
- Evapotranspiration
- Evaporation
- Infiltration

Anticipatory Set (Engage): Written on the board as students walk in to the classroom... Please answer the following questions in your journal... 1) where does water come from? 2) Have you personally ever been unable to access water when you needed it? (if yes, explain). “When
finished writing in your journal, turn to your partner and discuss what you each came up with as an answer.” Teacher asks students, “Would anyone like to share their answer(s)?” Teacher asks follow up questions to student responses… “So, where is water created and where does it stop, or end? Can we run out of water?” Teacher waits for students to answer (both questions create classroom discussion with different ideas). Teacher says, “Today, we will investigate to find the answers to these questions looking at water in a way that many of you have probably never looked at it before.”

**Purpose:** “The purpose of this lesson is to teach you how to successfully identify and understand the stages of the hydrologic cycle. Once this concept is understood, you will be able to apply this knowledge to become more responsible in your personal use and consumption of water. This is an extremely important issue in today’s society, as we are currently facing a water crisis in terms of water shortages throughout the nation. Much of the problem that has led to this water shortage is the lack of knowledge concerning effective practices of water usage and a true understanding of how the hydrologic cycle works. Therefore, learning the material presented in this lesson is extremely important step in order to help us conserve the most precious natural resource we have on earth, water.”

**Guided Practice:** Teacher shows video of hydrologic cycle (below). Teacher explains the process of the cycle as the video plays. [https://www.youtube.com/watch?v=iohKd5FWZOE](https://www.youtube.com/watch?v=iohKd5FWZOE)

Teacher supplements video with pictures of vocabulary words and of the hydrologic cycle on ‘Day 1 - Reflective Notes’ handout for further clarification and explanation of processes in the hydrologic cycle.

(Explain): Teacher discusses table of where fresh water is mostly stored and a diagram of the Hydrologic Cycle on ‘Day 1 - Reflective Notes’.

(Elaborate/Extend): Students will be asked to discuss in groups of 3-4 students to identify a potential problem on Earth with the newly acquired information given on all of the graphs and tables on the ‘Day 1 – Reflective Notes’. The problem(s) will be discussed as a class in tomorrow’s lesson. Teacher introduces ‘Day 1 - Writing to Learn’ assignment.

**Assessment (Evaluate):** Teacher makes a pre-assessment on the student’s prior knowledge of the water cycle through journal entries. Teacher introduces writing assessment for this unit (*See Day 1 Writing Activity Assignment & examples for quality of work*).

**Adaptations within the Inclusive Classroom:** In this lesson plan, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the notes are given with more pictures than words to accommodate visual learners, as well as auditory learners during the video and teacher explanation of the water cycle diagram. Secondly, students are asked to fill out reflection questions that are discussed in class so that each student will be able to identify main points of the lesson. Lastly, the writing to learn assignment is given to accommodate learners of all different interests by giving students a choice between creative writing, writing from research, and writing from personal experience.
Precipitation

Source: http://www.slideshare.net/hamza07/precipitation-presentation

Condensation

Source: https://www.windowssearch-exp.com/images/search?q=Examples+of+Condensation&FORM=RESTAB
Name: ___________________ Date: ____________

Water – Day 1 Reflective Notes

Evapotranspiration

Source: http://geography.about.com/od/climate/a/evapotranspirat.htm

Evaporation

Capillary Action

Source: http://lucytomkinson.blogspot.com/2011/03/capillary-action-further-tests.html

Infiltration

Source: http://nreca.cals.cornell.edu/soil/CA2/CA0211.1.php
Sublimation

All of these processes make up the...
Where is Earth’s Water?

(Or, if you prefer a different format classifying Earth’s water)…

The Reality…

Source: http://www.fewresources.org/water-scarcity-issues-were-running-out-of-water.html

**Reflection Questions:**

1) In your own words, what is the hydrologic cycle?

2) What are the processes involved in the hydrological cycle and an example of each?

3) What is a closed loop system?

4) Based on the information you have learned from today, what potential problem(s) do you see for life on planet Earth?
Water Cycle Writing to Learn

Choose 1 of the Assignments below…
Project Due Date: Must be complete before beginning PBL assignment

Assignment #1- Nature Journal
For this assignment, you are to communicate your knowledge of the water cycle to your classmates and your teacher using any form of communication you wish in the format of a nature journal. Assume that we know nothing about the water cycle for your project. Be sure to include (1) how the water cycle works (processes involved), (2) how it effects life on our planet, and (3) what you will do with your knowledge of the water cycle (ie. change some of your habits, propose ideas/solutions for water usage, etc.).

Please look at the rubric entitled “Nature Journal Rubric” to see the expectations and grading that will accompany this project. Some examples include taking pictures, drawing pictures, making videos, creating a song/rap, writing a poem, or any other idea that will effectively communicate your understanding of the water cycle to someone who is unfamiliar with it. Feel free to talk to your teacher with “any and all” ideas you have for this project. Although the rubric does not require creativity, the project may be easier on you (and easier for us to understand the concepts) by incorporating creativity into your project.

Assignment #2- Water Cycle Story
For this assignment you will be using your knowledge of the water cycle processes and creative writing skills to produce a story that illustrates the water cycle. You can present the information any way you like but your story must include the terms: Precipitation, Groundwater, Infiltration, Evapotranspiration, Evaporation, Condensation, Runoff, Capillary Action, and Water Storage.

Be creative! You might be a microscopic water molecule on a trip through the water cycle or a late night talk show host interviewing a hydrologist. You could include characters from your favorite movies and take them on a water cycle adventure. The possibilities are endless, just have fun with it.

The goal of this paper is to write a fun yet informative piece about the water cycle. This will require a narrative style that provides visualization and draws your reader in. Also keep in mind that in order to create a sensible storyline that your readers can follow, you must organize your piece in a logical sequence.

Assignment #3: Research Paper
Write a research paper of approximately 3-5 pages on the hydrologic cycle. The paper shall explain (1) the definition and process of the hydrologic cycle, (2) its importance on the habitability of Earth, and (3) the impact humans have on the hydrologic cycle. The paper shall include a minimum of two resources, not including the class textbook, cited in the paper and referenced in the paper’s Bibliography.
DAY 2- WATER: The Importance of Water and the Hydrologic Cycle

Lesson Objective(s): (Same as Day 1).

Websites Used:
http://interactivesites.weebly.com/clouds--water-cycle.html
http://water.usgs.gov/edu/watercycle-kids-adv.html
http://www3.epa.gov/safewater/kids/flash/flash_watercycle.html
http://www.discoverwater.org/blue-traveler/

Anticipatory Set (Engage): In groups of 3, the students explore the interactive websites (referenced above) regarding the water cycle at different stations to reinforce their understanding of all of the processes involved. Each group is given 5 minutes per station to explore a website.

Purpose: (Same as Day 1)

Guided Practice: The teacher walks around room, discussing each website activity, asking reflective questions, and answering each group’s questions.

(Explore): Students explore each website for 5 minutes, totaling 20 minute of class time.

(Explain): Teacher brings class back to classroom seats and asks students to share answers to question #4 on ‘Day 1- Reflective Notes’. Teacher writes responses on board. Teacher facilitates discussion on how a fixed amount of water needs to supply a continually growing population and how this leads to a situation known as a water crisis.

(Elaborate/Extend): n/a (continuation from Day 1)

Closure: Students watch you tube videos below demonstrating water crisis followed by Q&A discussion on videos.
https://www.youtube.com/watch?v=BCHhwxyQqxg
https://www.youtube.com/watch?v=vSz9IRbl_0I

Assessment (Evaluate): Teacher will make informal assessments of student’s knowledge during class and group discussions. Teacher makes individual assessments of student’s knowledge on water cycle after reading their ‘Writing to Learn’ assignment.

Adaptations within the Inclusive Classroom: In this lesson plan, students are being taught from a multi-sensory approach, including hands-on, auditory, and visual learners. The students are also grouped so that there is a wide range of abilities within the group (ex. one student is a strong reader, one student has strong social skills, one student has high content knowledge).
DAY 3- WATER: Groundwater Characteristics

**Lesson Objective(s):** The learners will apply inquiry methods to learn about the concept of groundwater flow, with an emphasis on the permeability and porosity of different types of rock and soil.

**New Vocabulary Words:**
*Permeability*
*Porosity*

**Anticipatory Set (Engage):** On the table, as students walk in the classroom, are the following materials…
- Gravel in a container
- Clay in a container
- Sand in a container
- Potting soil in a container
- 4 Test tubes
- 100 ml glass beakers
- small funnels
- 100 ml graduated cylinders

Teacher says, “Everyone get with your partner (partners written on board), and make a prediction on which of these materials (Gravel, Clay, Sand, Potting soil) you think water will pass through the quickest by numbering them 1 through 4; with 1 being the material water will pass through the quickest, and 4 being the material water passes through the slowest. After you make this first prediction, I would like you to make a second prediction, which of these materials has the most voids (air pockets) in it. Number your predictions as 1 for the material with the most voids, and 4 for the material with the least amount of voids. Support your educated guesses with a reason (hint: did you notice any relationship between your two predictions?), and these two predictions will become your hypothesis for our upcoming experiment today.”

**Purpose:** The purpose of this lesson is to teach students the basic characteristics of groundwater flow. Groundwater, makes up about 98 percent of all the usable fresh water on the planet, and it is about 60 times as plentiful as fresh water found in lakes and streams. Because groundwater is not visible (in most cases), it is often overlooked when considering all of the water on Earth, and yet, water beneath the land surface is a valuable resource. Protecting it from contamination and exhaustion by carefully managing its use will ensure its future as an important part of ecosystems and human activity. Our future generations must learn about the basic characteristics of groundwater to make informed decisions to avoid contamination and exhaustion of this natural resource that is essential to all types of life.

**Guided Practice:** The teacher tells the students that the first prediction they made, deals with a term called *permeability*- the ability of fluids to travel through rock or soil, measured in m$^2$ or cm$^2$. The second prediction they made, deals with a term called *porosity*- the amount of pore space present in rock and soil, measured as a percentage (%).
(Explore): Teacher says, “Now that you have made your two hypotheses, you and your partner will design two separate procedures to prove the validity of each of your hypotheses. Using the materials on the front desk, you will need to create a way to show the time it takes for water to pass through a given material in the first experiment (permeability), and create a way to show the amount of pore space in a given material in the second experiment (porosity).

(Explain): Teacher walks around room to evaluate and guide students in their design process. Teacher consults with each group individually to make sure they begin to understand the concept of permeability and porosity. If the majority of the class is making similar mistakes in this open-ended activity, the teacher would then bring the class together to go over common misconceptions or misunderstandings to make the lesson more effective.

(Elaborate/Extend): After the students are given sufficient time (approx. 20 minutes), the teacher brings the class back together to discuss the connection that this inquiry-based lab makes with the topic of groundwater. The teacher explains that groundwater, defined as water that is found beneath the water table under Earth’s surface, travels through pores in soil and rock, in fractures, and through weathered areas of bedrock from high areas to low areas. The teacher allows the students in the lab to make the connection between permeability and porosity - as permeability and porosity measurements in rock and/or soil can determine the amount of water that can flow through that particular medium. A “high” permeability and porosity value means that the water can travel very quickly. After the teacher and class discuss the important connections between permeability and porosity with groundwater flow, ‘Day 3 Groundwater Characteristics handout’ is given to the students so that they can reflect on the important concepts learned in the lesson, and prepare for the PBL activity with some foreshadowing reflection questions.

Assessment (Evaluate): Teacher asks students to write up their lab procedure that they created today for homework, as well as completing the reflection worksheet. Teacher makes an informal assessment of the students while conversing with each group, as well as a formal assessment that will be counted for a grade on the students lab write-up, as well as the students answers to the reflection worksheet.

Adaptations within the Inclusive Classroom: In this lesson plan, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the teacher pairs students so that productive discussions will engage each student. Second, the directions to the assignment are given both verbally and written on the handout, as well as modeled to the class to accommodate many different learning styles.
Porosity and Permeability Activity Sheet

A. Complete the following table:

<table>
<thead>
<tr>
<th>Material</th>
<th>Total Volume (milliliters)</th>
<th>Pore Space (milliliters)</th>
<th>Porosity (% Pore Space)</th>
<th>Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Soil</td>
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</tr>
<tr>
<td>Clay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Porosity = (Pore Space ÷ Total Volume) x 100

B. Make bar graphs of your results. Label the axes on your graphs (don’t forget to add the units).

* Remember, the material through which water takes the longest time to flow is the LEAST permeable.

C. Answer the following questions:

1. Which material is most porous? __________________________

2. Which material is least porous? __________________________

VOCABULARY

Permeability –

Porosity -

ACTIVITY

You will create two (2) separate lab procedures that will verify the hypotheses you and your partner made concerning the permeability (lab procedure #1), and porosity (lab procedure #2) of the following samples; gravel, clay, sand, and potting soil. In these lab procedures you must have the following…

Introduction - defines permeability and porosity and how they relate to groundwater flow.

Hypothesis – Your predictions on which material is more/less permeable and which material has a higher/lower permeability (these educated guesses must be backed up with reasoning).

Methodology – You will write up two procedures here (one for finding out the permeability of a substance/material, and one for finding the porosity of a substance/material). The procedure must be clearly written so that someone who knows nothing about this topic would be able to successfully conduct the experiment base on your directions/procedures.

Data – Fill out the data sheet given on the back of this handout

Results – What did you find out about the permeability and porosity of the different materials used? Did you notice a relationship between permeability and porosity with water flow? Explain!

REFLECTION QUESTIONS:

1. List 3 things you learned about groundwater flow during today’s activity?

2. Why do you think it is important to know about groundwater flow?

3. If you drilled a well in the materials that were tested for permeability and porosity in this experiment, which one do you think would yield the most water?

4. How does soil type affect the movement of groundwater?

5. How do you think soil can help protect groundwater from pollution?
DAY 4 - WATER: Aquifer Models

Lesson Objective(s): The learners will create a model of a specific type of aquifer and be able to label the different working parts of the aquifer and explain their functions.

New Vocabulary Words:
Confined Aquifer
Unconfined Aquifer
Water Table
Artesian Well
Perched Groundwater
Confining Bed
Recharge
Saturated Zone
Unsaturated Zone
Potentiometric Surface

Anticipatory Set (Engage): On the table, as students walk in the classroom, are the following materials…

- Container (5 gallon to 10 gallon glass or plastic aquarium)
- Plastic tubing
- Pump from a liquid soap container
- Panty hose, screen, or cheese cloth
- Household sponges
- 5-gallon bucket of sand
- 5-gallon bucket of gravel
- Outdoor carpeting
- Modeling clay
- Watering bucket

Purpose: The purpose of this lesson is to teach students how groundwater is stored in the ground, and extracted from the ground using various types of well systems. Knowing how groundwater is stored underground will help us protect it from contamination and exhaustion by carefully managing its use and will ensure its future as an important part of ecosystems and human activity. Our future generations must learn about the underground storage of groundwater to make informed decisions in order to avoid contamination and exhaustion of this natural resource that is essential to all types of life.

Explain: The teacher discusses different types of aquifers and wells on the smartboard by showing a 2-D model of each aquifer type on the screen (See ‘Day 4 Aquifer Activity Handout’). After a brief introduction to the different types of aquifers that exist, the teacher invites the students to get in groups of three’s and create a model aquifer of whichever type of aquifer (confined, unconfined, or perched) they are given by the teacher for this lesson.
**Guided Practice:** Students will first look at many different 2D-models of aquifers on the computer (Google Images) to find which diagram is the most clear in showing the differences between the aquifers. Students will then work together to build their 3-D model aquifer with the materials given on the table. When groups are finished making their models, the teacher goes around to each group and discusses the model that each group made to the class so that all types of aquifers are explained to the class.

(Elaborate/Extend): Students are asked to complete their Reflection Questions on ‘Day 4 Aquifer Activity’ handout and individually draw a picture of the model they made and labeling the different parts or systems on their drawing and explaining its function. The Reflection sheets also have questions on them that will test the student’s understanding of how aquifers work, the different processes that occur to keep the aquifer functioning (keeping water in the aquifer), and how to extract water from each aquifer (different types of well).

**Assessment (Evaluate):** Teacher informally assesses the students while they work on their model to see if they understand the features and concepts that contribute to aquifers and well systems. A formal assessment will be made on each of the group’s aquifer model, as well as the student’s answers to the reflection worksheet.

**Adaptations within the Inclusive Classroom:** In this lesson plan, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the directions to the assignment are given both verbally and written on the handout, as well as modeled to the class to accommodate many different learning styles. Secondly, the teacher assigns pre-determined groups to be used in this activity so that students who show a strong understanding of this material can work with students who may need more support.
Name: ________________________  Date: ____________

Water: Day 4 Aquifer Activity

**VOCABULARY**

Confined Aquifer –

Unconfined Aquifer –

Water Table –

Artesian Well –

Perched Groundwater –

Confining layer –

Recharge –

Saturated Zone –

Unsaturated Zone –

Potentiometric Surface –
ACTIVITY

You are to create a model that shows the different features that make up an aquifer, which will also include a well system that will draw water from the aquifer. Each group will be given a certain type of aquifer that they will have to create a model for. You will then draw a diagram of all of the different types of aquifer models created in the class in the space below (you do not need to duplicate drawings of the same aquifer type, as some groups and answer the remaining questions below your diagrams.

MODEL DRAWINGS:

Group # ______
Aquifer Type: _________________________   Well Type: _________________________
Draw the layers of this aquifer in a profile view (horizontal cross section) and label your drawing with all applicable vocabulary words listed above:

Group # ______
Aquifer Type: _________________________   Well Type: _________________________
Draw the layers of this aquifer in a profile view (horizontal cross section) and label your drawing with all applicable vocabulary words listed above:
Group # ______
Aquifer Type: _________________________ Well Type: __________________________
Draw the layers of this aquifer in a profile view (horizontal cross section) and label your
drawing with all applicable vocabulary words listed above:

REFLECTION QUESTIONS:
1. What are the differences between a confined aquifer, an unconfined aquifer, and a perched
   aquifer?

2. Which type of aquifer do you think would make the best source to put a well? Why?

3. What factors are to be considered when selecting a site to drill a well?

4. What time of the year do you think aquifers may have less water contained in them in the
   northeastern U.S.? What time of the year do you think aquifers contain the most water in the
   northeastern U.S.?

5. What are some types of contamination that may infiltrate into groundwater?
DAY 5 - WATER: Water Budget

Lesson Objective(s): The learners will model the seasonal fluctuations of the groundwater table at a specific location to understand the terms and changing conditions associated with a groundwater budget table.

New Vocabulary Words:
Flood
Drought
Potential Evaporation (PE)
Precipitation (P)
Soil Moisture (ST)
Soil Moisture Deficit (D)
Soil Moisture Surplus (S)
Actual Evapotranspiration (AE)

Anticipatory Set (Engage): The following You-Tube video is shown to engage the students in the lesson plan that will be given today by reviewing global warming and foreshadowing the upcoming PBL project…

On the table as students walk in the class are the following materials…

- 24 Containers (1 gallon to 3 gallon glass or plastic aquarium)
- Household sponges
- 5-gallon bucket of sand
- 5-gallon bucket of gravel
- Outdoor carpeting
- Modeling clay
- Watering bucket

Purpose: The purpose of this lesson is to teach the students how groundwater fluctuates throughout a given year at different locations throughout the world. Knowing how groundwater fluctuates throughout the year will help us understand and potentially predict natural disasters such as flooding and droughts, allowing us to better prepare for them in the future.

Guided Practice: Teacher invites students to get into twelve (12) pairs for the next activity. Students are each handed a groundwater budget handout to aid them in the activity (See Guided Practice section of ‘Day 5 Water Budget Handout’). Each pair of students represents a particular month at a given location. In front of each pair of students are the items to be included in a groundwater model for that particular month. This is a class activity, where the teacher aids each pair of students (one at a time, as all students pay attention to the particular group that is demonstrating, from Jan. to Dec.) in the addition/subtraction of water that the groundwater budget indicates for that particular month. Teacher goes over with students by showing the students in each month’s model what the terms on the groundwater budget handout are referring to, and how each month’s groundwater conditions affect the next month’s conditions. Once each group has modeled the groundwater conditions for their month with the teacher, the students are
given an opportunity to do this on their own to model for the teacher their understanding of the groundwater budget table.

(Explore): Students are asked to model a new groundwater budget at a different location than previously given (See Student Practice section of ‘Day 5 Water Budget Handout’. Each pair of students represents a particular month at a given location, as before. In front of each pair of students are the items to be included in a groundwater model for that particular month. This is a class activity, again, where the students work in pairs on what changes they will be making to their water table, and then will demonstrate for the class when it is their time to show the changes in the groundwater table in their particular month. Teacher will listen closely to each group’s discussions/explanations to make sure students understanding is correct, and, if not, then the teacher will get involved in the discussion to help lead the students to the correct understanding of the groundwater budget table.

(Explain): Teacher will listen closely to each group’s discussions/explanations to make sure students understanding is correct, and, if not, then the teacher will get involved in the discussion to help lead the students to the correct understanding of the groundwater budget table. Each pair of students designated for each month, will explain successively from Jan. to Dec. what happens to their groundwater table by explaining and showing the class when it is their turn.

(Elaborate/Extend): Students are asked to complete their Reflection questions to ensure they are understanding the concept of the groundwater budget tables and how to correctly fill them out given the necessary information. The Reflection sheets have questions on them that will test the student’s understanding of how the tables work and the different processes occur that cause fluctuation in the groundwater table, causing drought or flood conditions.

Assessment (Evaluate): Teacher informally assesses the students while they work on their models in pairs to see if they understand the features and concepts that contribute to the fluctuation of the groundwater levels given the necessary data of a specific location at a specific time. Another informal assessment will made on each of the group’s aquifer model, as well as a formal assessment on the students answers to the reflection worksheet that is to be done as homework if not finished in class.

Adaptations within the Inclusive Classroom: In this lesson plan, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the directions to the assignment are modeled to the class so that students can get a good “feel” for what they are supposed to be doing and what the numbers and new vocabulary, in this particular assignment, represent. Second, the teacher assigns pre-determined groups to be used in this activity so that students who comprehend the material quickly can work with students who may need extra support. Lastly, the class discussions between teacher and each student group representing each month have been written on the handout so that students can refresh their memory of what was discussed in class in case they forget, or use this information to study independently.
VOCABULARY

Drought –

Flood –

Potential Evaporation (PE) –

Precipitation (P) –

Soil Moisture (ST) –

Soil Moisture Deficit (D) –

Soil Moisture Surplus (S) –

Actual Evapotranspiration (AE) –

Rules of the Water Balance

1] AE is never greater than PE

2] When the demand is met (when P = or > PE), AE always equals PE.

3] However, when P < PE, the water demand has not been met. Water has to come from somewhere to meet the demand.
If there is soil moisture stored (left over soil moisture [ST] from the month before), that is where the water will come from first.
So in the case where P<PE, the 'missing' water will come out of the soil moisture of the previous month.
In this case, AE = P + change in ST (the water taken out of storage to meet demand).
If the demand is met through P and change in ST, you will notice that P + change in ST will be the same value as PE.

4] If P < PE and there is enough soil moisture to make up the demand, you’ll have AE = P + change ST.
Ex: P = 2, PE = 5, P-PE= -3
We need 3 inches of water to meet the demand of the environment.
If soil moisture was 4 in the previous month, we could meet the demand by taking those 3 inches we need (P-PE= -3) out of the soil.
In this case, AE = P + change ST (AE = 2 + 3 ………so AE =5)
We met the demand (PE) this month by getting 2 inches of rain and taking 3 inches out of the soil. We even have 1 inch of soil water left over this month to carry over into the next month! This is important because if PE is not met again next month, we’ll have some ‘extra’ water to help out just as we did this month.

5] What do we do when P < PE and we don’t have enough soil moisture to help meet PE?
If P < PE and there is not enough soil moisture to make up the demand, you’ll have a deficit.
Ex: P = 2, PE = 5, P-PE = -3
If the soil moisture (ST) from the previous month was 2 inches, you’ll use ALL of that water to meet the demand.
However, you needed 5 inches (PE=5) to meet the demand of the environment. You only got 2 from precipitation, and 2 from the soil, so you have a deficit of 1 inch.
This month, D=1.
AE = P + change ST but there simply isn’t enough water, so AE = 4 in this situation.
When P<PE and ST isn’t enough to help meet the demand, you will have a Deficit and AE<PE for that month

6] You will only have a Surplus (S) when P>PE and ST is at capacity.

7] You will only have a Deficit (D) when P<PE and ST is empty (at zero)

8] When calculating AE, always take the absolute value of the number used. Ex: if P<PE, AE will equal P plus the absolute value of change ST.

9] Lastly, check your work before submitting your answers. Use the equations below to double check your work.
If the numbers add up and equal, you’ve done your Water Balance correctly. If they do not, send me an email and we’ll see where you went astray.

In these equations, be sure to use the annual totals for P, PE, AE etc.

\[ P = AE + S + \text{change ST} \quad \quad \quad PE = AE + D \]

Example of Groundwater Budget Table for Oxford, MS (2008) (GUIDED PRACTICE)-

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<thead>
<tr>
<th></th>
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<th>MAY</th>
<th>JUN</th>
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<td>0.02</td>
<td>0.18</td>
<td>1.48</td>
<td>2.73</td>
<td>4.18</td>
<td>5.73</td>
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<tr>
<td>P</td>
<td>9.68</td>
<td>6.46</td>
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<td>16.47</td>
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<td>1.45</td>
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<td>P-PE</td>
<td>9.66</td>
<td>6.28</td>
<td>4.44</td>
<td>13.74</td>
<td>-.02</td>
<td>-4.28</td>
<td>5.63</td>
</tr>
<tr>
<td>ST</td>
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<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
<td>5.98</td>
<td>1.70</td>
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</tr>
<tr>
<td>Change ST</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>-.02</td>
<td>-4.28</td>
<td>4.30</td>
</tr>
<tr>
<td>AE</td>
<td>0.02</td>
<td>.18</td>
<td>1.48</td>
<td>2.73</td>
<td>4.18</td>
<td>5.73</td>
<td>6.76</td>
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<td>------</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S</td>
<td>9.66</td>
<td>6.28</td>
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<th>ANNUAL</th>
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<tr>
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<td>6.22</td>
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<td>P</td>
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<p>| | | | | | | |</p>
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<tr>
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<td>0.27</td>
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<td>0</td>
</tr>
<tr>
<td>AE</td>
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<td>4.01</td>
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<td>0</td>
<td>5.60</td>
<td>2.22</td>
<td>47.05</td>
</tr>
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</table>

**Explanations...**

**January:** in this month P is > PE so we have met the water demands of the environment. Since the soil moisture is at capacity (ST =6), all water goes straight into runoff or surplus (S)

**February:** again, in this month the demand has been met because P>PE. Soil moisture is still filled to capacity so no water is needed to replenish any lost soil moisture. All water (P-PE) goes straight into surplus (S).

**March:** once again, P>PE and the water demand has been met. No water is lost to replenishing soil moisture (ST) so all water goes into surplus (S).

**April:** P>PE so the water demand of the environment has been met for the 4th straight month. No water is lost to replenishing soil moisture (ST) so all water goes into surplus (S)

**May:** This is the first month where the demand (PE) has not been met by rainfall alone (P). P-PE = -0.02. Therefore, to make up for the missing 0.02 inches, and to meet the water demand of the environment, we’ll have to get this from soil moisture (ST). So, we’ll take out 0.02 inches from the soil filled at capacity (at 6 inches). 6 - 0.02 = 5.98. In this month we have a change in ST of –0.02. This is the first month of the year where our ST is not filled to capacity but we still have a good bit of soil moisture since we have 5.98 inches of water in the soil.

**June:** Once again, we won’t meet the demand (PE) by P alone. In this month, P-PE = -4.28. Since we didn’t meet the demand via rainfall, we’ll have to use more soil moisture. Last month, we had 5.98 inches of water left over. Since we need 4.28 inches to meet the demand this month, we’ll have to take all 4.28 inches from the soil. (Luckily we have it to take! Otherwise, we’d have a deficit!). So 5.98 - 4.28 = 1.70. This means that we have 1.7 inches of water left in the soil after taking out 4.28 inches needed to meet the demand. However, now we’ve really
tapped into the soil water to meet the demand. We only have 1.7 inches of soil water left. Change in ST this month = -4.28 because we had to take 4.28 inches of water out of ST.

**July:** This month, P>PE so the demand is met. Where is the extra water going to go? Straight into replenishing the soil moisture that we took out in the past couple of months. P-PE = 5.63 inches this month. We only have 1.7 inches left in ST and we want to bring it up to its capacity of 6. 6-1.70 = 4.3. We need 4.3 inches of P-PE to bring ST back to its maximum of 6 inches. So, change in ST is going to be 4.3. But if we only ‘need’ 4.3 inches, we had 5.63 to work with. (Remember that P-PE was 5.63). So we actually have a surplus of 1.33 inches when we consider that 5.63 - 4.3 = 1.33. This 1.33 inches is the moisture left over AFTER the demand of the environment was met, AND after soil moisture was replenished.

**August:** P-PE is negative (-2.58) so the water demand of the environment was not met. This 2.58 inches will need to be taken from ST. Luckily, our ST was at maximum after last month. So, ST this month is going to be 6 - 2.58 = 3.42. Since 2.58 inches of water was removed from ST to meet demand, change in ST = -2.58.

**September:** since P>PE, we have some extra moisture to work with after the demand has been met. Since ST is not at maximum (6 inches) we need to replenish ST. Any moisture leftover will go into surplus (S). P-PE = 6.36 this month. ST was only 3.42 at the end of last month and we want it to be at maximum so 6-3.42=2.58. We need 2.58 inches to bring ST back to capacity. After we use 2.58 inches to replenish ST, we still have 3.78 inches of moisture leftover because 6.36-2.58=3.78. This ‘extra’ moisture goes into surplus. So, S = 3.78 and ST is back at 6. This month, change in ST =2.58.

**October:** P<PE so the demand is not met. P-PE = -0.27 so we’ll need to get this from ST. Since ST is at 6 inches, 6-0.27 = 5.73. ST this month is 5.73, change in ST is –0.27 because we removed 0.27 inches from soil moisture to meet demand.

**November:** P>PE so the demand is met. P-PE =5.87. The first thing we need to do is replenish ST. How much moisture is needed to bring ST back to capacity? Well, if capacity is 6 inches, and we had 5.73 inches last month, we’ll need 0.27 inches to get back to capacity: 6-5.73=0.27. Since P-PE was 5.87, 5.87-0.27=5.60. This means that after replenishing ST, we’ll have a surplus of 5.60 inches.

**December:** P>PE so demand is met. ST is at capacity from last month, so all P-PE goes into surplus. Surplus = 2.22 inches.

**Example of Groundwater Budget Table for Houston, TX (2008) (STUDENT PRACTICE)**-

<table>
<thead>
<tr>
<th></th>
<th>JAN</th>
<th>FEB</th>
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<th>APR</th>
<th>MAY</th>
<th>JUN</th>
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<td>PE</td>
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<td>1.98</td>
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<td>-0.86</td>
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### REFLECTION QUESTIONS:

1) Using the data below (in inches), calculate the Water Balance for Starkville, MS. Assume that 6 inches is saturated soil [soil holding its maximum water load].

<table>
<thead>
<tr>
<th>ST</th>
<th>6.0</th>
<th>6.0</th>
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<tr>
<td>AE</td>
<td>0.04</td>
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<td>0.97</td>
<td>1.39</td>
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</tbody>
</table>

137
1) Were there any soil moisture deficits (D) in the Water Balance? Explain why or why not.

2) In general, when is soil moisture (ST) depleted? Why?

3) In what months did you observe a surplus of water (S)? Why did we have surplus water in these months?

4) In what months was PE highest? Is there a seasonal cycle to PE? Explain.

5) Balance your water balance calculations using the equations given in the lecture & text. Did your equations balance? What does this tell you?

6) In what months was soil water (ST) depleted? Why?

7) In what months was soil water (ST) being recharged or replenished? Why?
**DAYS 6-10 - WATER: PBL “THINK INDIVIDUALLY, LOCALLY, AND GLOBALLY”**

**Lesson Objective(s):** The learners will combine research, problem-solving, and team working skills to design solutions to the water crisis the nation is currently experiencing at the personal, municipal, and global level.

**Anticipatory Set (Engage):** Handout and introduce PBL Project (See all PBL Project Handouts attached).

**Purpose:** The purpose of this PBL assignment is for students to build from what they have learned through direct instruction (Blooms knowledge level) about the water cycle by designing solutions (Blooms application level) to the water crisis at different levels of severity.

**Guided Practice:** After explaining the PBL assignment, the teacher now becomes a facilitator in the classroom and allows students to collaborate together to come up with a solution to various problems causing the water crisis.

(Explore): Students utilize both hard and soft scaffolds (if needed) from the teachers to come up with possible solutions to the PBL activity.

(Explain): Teacher may explain different concepts to different groups on specific questions asked, but only when teacher feels this is necessary to avoid misconceptions.

(Elaborate/Extend): At end of PBL assignment, each group will present the findings to teach other groups about possible solutions and causes/effects of each specific solution.

**Assessment (Evaluate):** Students will be graded based on PBL Rubric as well as by peers and self through different reflection worksheets on project.

**Adaptations within the Inclusive Classroom:** In this lesson plan, there are a few things that have been adapted to make it a more successful learning experience for all students. First, the directions and expectations of this PBL assignment are given both verbally and written on the handout, available on iPads for “text to voice” feature, as well as modeled to the class to accommodate many different learning styles. The group is monitored to work together, and if there are any components in this activity that cannot be completed by a student, another group member can complete that part, and the other student may work on a separate piece of the activity. Lastly, if particular students have trouble speaking in front of the class, the teacher will help the student present by asking questions and continually providing breaks in the speaking so the student can have time to process his/her thoughts.
**Name: ________________________  Date:_____________**

**Water: PBL Project Intro**

**TASK:** As a class, we have identified that there is a major water crisis on our planet today. With a growing population, and a fixed amount of water, the problem will only become worse. In this investigation, we will look at possible solutions that will help EVERYONE have access to clean drinking water. Remember, **climate is variable; we can’t control the amount of precipitation** we receive in a given area each year. Therefore, **we need to be more efficient, innovative, and conservative of clean water when and where we have it.**

**PURPOSE:** We are investigating a major area of concern in the world today. Without solutions to ease this crisis, the world population is looking at more disease, death, and turmoil. Water is necessary for human life to flourish; it is of higher necessity than oil, gold, and all the riches in the world. Due to living in an area with an abundance of water, we may be less aware of this crisis than we need to be in order to make the necessary changes. This PBL project will help us understand the problem of the water crisis and design possible solutions to help everyone have access to clean water.

**PROCEDURE:** Teacher will assign students to one of three teams: “THINK INDIVIDUALLY, THINK LOCALLY, and THINK GLOBALLY”. Each team will work together for the next six days to research, collect, organize, and eventually present information on possible solutions to help fix the water crisis on an individual, local, and global level. To help each team stay on task, there will be a “guided schedule overview” as well as a more descriptive “task guideline” to follow each day to help each team work efficiently and meet all the requirements for this project. Task guidelines will be broken down into sub categories of *Required (must be complete), ^Recommended (students are encouraged to complete), and @Optional (if extra time prevails). In addition, each team member will have a specific job to do to ensure team success and help facilitate communication between team members. Teams may work ahead if granted permission by teacher.

**Key for Task Guidelines:**
- *Required – indicated by * symbol. Students need to do these types of tasks.
- ^Recommended - indicated by ^ symbol. Students are encouraged to do these types of tasks.
- @Optional - indicated by @ symbol. Students can choose to do these types of tasks if other tasks are complete.

**GRADING:**

5- See expectations on PBL rubric for grading information.
6- At the end of this project students will be asked to hand in…
   a. Reflection Questions and team notes in organized manner
   b. Final Presentation (if it something that is able to be turned in)
   c. Peer Evaluation grade
   d. Self-Reflection grade
GUIDED SCHEDULE OVERVIEW:

DAY 6 (Today):
5) Meet your assigned team members
6) Be present for introduction and Q&A session about this PBL assignment
7) Assign different job assignments to team members (see PBL Job Assignments).
8) Review all different handouts (Guided Schedule, Team Specific Task Guideline, and Project Checklist) to ensure scope of work and expectations are clear between team members and teacher.
9) Review/Discuss Concept Map when ready!

DAYS 7-10:
5) Follow Team Specific Task Guideline
6) Be 100% ready to present on Day 11 (approved by teacher)

DAY 11:
3) Each team presents findings from completing their Task Guideline
4) Each student answers past Regents exam questions on water

DAY 12:
3) Reflect on project as a class
4) Fill out peer reviews and self-reflection grades
PBL JOB ASSIGNMENTS

12) Time Keeper: Is responsible for…
   - keeping team on task
   - giving reminders about time remaining in class and on project (reviewing schedule overview with team)
   - any other jobs/responsibilities team feels is appropriate

13) Project Manager: Is responsible for…
   - keeping team on task and ensuring all students know their roles/jobs
   - assigning student roles based on student ability and strengths
   - being a leader (not boss) to ensure team productivity
   - any other jobs/responsibilities team feels is appropriate

14) Team Reporter: Is responsible for…
   - recording information for team through notes, ideas, outlines, etc.
   - documenting any information team feels is valid
   - any other jobs/responsibilities team feels is appropriate

15) Team Organizer: Is responsible for…
   - Organizing all group materials
   - any other jobs/responsibilities team feels is appropriate

16) Team ‘Toolbox’: Is responsible for…
   - Any additional jobs that don’t fall under a specific category above (i.e. running errands, communicating to teacher concerns of group, collaborating with other groups, etc.)
   - May have 2-3 of these positions if team consists of 6-7 students.

NOTE: Students will need to be flexible in adapting or taking on more responsibility than just the role he/she picks at the discretion of the team. For example, time keeper will also be responsible for contributing to team discussions, as well as making sure team is adhering to time schedule. All students are expected to contribute 100% effort to help each team work as effectively as possible.
Name: __________________
Date: ____________
Water – PBL Team Checklist

PBL CHECKLIST

Directions: Be sure teacher signs each step before moving on to the next step!

Class Period: _____
Team Name: ____________________ (ex. Team H$_2$O)

24) ___ Team has good understanding of PBL expectations, PBL rubric, and schedule of project.

25) ___ Every student is assigned to a group for this project.

________________________ - Time Keeper
________________________ - Project Manager
________________________ - Team Reporter
________________________ - Team Organizer
________________________ - Team ‘Toolboxes’

26) ___ All required steps/activities are complete on each team’s ‘Task Guideline’

27) ___ All ‘Guiding Questions’ are answered completely and accurately.

28) ___ All materials are organized in a way that makes presentation clear and effective.

29) ___ Teams/Individuals have completed recommended and/or optional activities (if time permitted).

30) ___ Team has re-visited PBL Rubric for expectations on presentation.

31) ___ Team is 100% ready to present!
DAY 6:

*Assigning different roles for team members: Each student will have a different role/responsibility within the group. See roles/responsibilities on ‘PBL Job Assignments’ handout…

*Review/Organize: Review all materials handed out and discuss scope of work and expectations as a class and group with teacher.

*Team checklist: Use this ‘PBL Checklist’ as a guide to keep your team on track and communicate with each other on the progress your team is making. Team will check off each line on each step when complete and the teacher will initial below each checkmark with approval so that the team may continue on to the next step.

*Build Background Knowledge of Problem: There are a few websites you will want to explore as a team before you get started on your concept map (next step). Take this first day and explore each website to review information or build off what you have already learned (this should take you the remainder of the period, there is a lot of information to explore on these websites!).

http://water.usgs.gov/edu/
http://www.fewresources.org/water-scarcity-issues-were-running-out-of-water.html
http://water.org/water-crisis/water-sanitation-facts/

*Begin when ready!: Review and begin filling in ‘Day 6 Concept Map’ when ready!
Water: Day 6 ‘Think Individually’ Concept Map

‘Think Individually’ Concept Map: Let’s organize our ideas…

PROBLEM: Not everyone has access to clean water which is essential for life.

CAUSE: Growing Population, fixed amount of water supply

EFFECT #1:  

EFFECT #2:  

EFFECT #3:  

INDIVIDUAL SOLUTION: (What can we do as individuals to solve or help the problem?)

IDEAS: 
Water Footprint?  

IDEAS: 
Educate / Involvement?  

IDEAS: 
Any others?
DAY 7:
*Water Footprint:* Use the provided website to calculate your water footprint (same idea as carbon footprint...only with water).

@**Make a model of your design:** Take your idea(s) from the water footprint activity and make a model, showing how your idea would work (ex. Drawing, 3-D model, etc).
**Water Footprint:** Use the website below to answer all questions (make educated guesses when needed) to calculate your household water footprint (you will be taking an average of all your team members answers to come up with an average water footprint of your team). When finished, explore ways to reduce your teams’ household water footprint. Use the questions below to aid in your note taking and be sure to print off your water footprint results when finished.


**REFLECTION QUESTIONS:**

1) In what areas did your team use the most water?

2) In what ways can you reduce your water usage in this area?

3) In what areas did your team use the least water?

4) What has your team been doing to use such little water in this specific area?

5) Why does the website ask for the user’s address? (Why might this effect one’s water use?)

6) Which results surprised you the most in this activity? Explain why.
**Water: Day 7 Household Water Footprint**

**Directions:** Find 5 ideas for limiting water usage at your home. Two examples have been provided to get you started. Use research methods to get you started, or to see if your idea is already being utilized!

<table>
<thead>
<tr>
<th>Wasteful Water Usage</th>
<th>Idea for Improvement</th>
<th>Effect of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 10+ minute showers of</td>
<td>1) Timer on Shower Valve</td>
<td>1) Acts as reminder to get out shower when timer goes off (i.e. shorter showers).</td>
</tr>
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</table>
DAY 8:

^**Read Story:** Read the story in the URL below on developing a town and the importance of water. Reflect as a team on the obstacles that 3rd world countries are facing. Why isn’t it as simple as this story makes it sound in developing a town/city with access to clean drinking water?

**http://water.usgs.gov/edu/dryville.html**

* **Wastewater:** Where does your household wastewater go? Complete the handout entitled “Water: Day 8 Wastewater Options”.

@**Research:** What is World Toilet Day? Research and write a 1 page reflection on what World Toilet Day is and why it exists!
Water: Day 8 Wastewater Options

Directions: Research different alternatives for recycling household wastewater (a link has been provided to get you started in your research). Describe the pros and cons for these different methods detailing the general overview of each process. Lastly, research methods being implemented in 3rd world countries and write pros and cons for such a process (an example has been provided).

Aerobic Wastewater Treatment…

Anaerobic (Septic Systems) Wastewater Treatment…
http://www.sourcewaterpa.org/?page_id=2632

Sanitary Sewer Wastewater Treatment…

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
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</thead>
<tbody>
<tr>
<td>1) Aerobic Wastewater Treatment</td>
<td></td>
</tr>
<tr>
<td>2) Anaerobic Wastewater Treatment (septic)</td>
<td></td>
</tr>
<tr>
<td>3) Sanitary Sewer</td>
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</tbody>
</table>

What is stopping these types of systems from being implemented in 3rd world countries?
http://www.theguardian.com/sustainable-business/future-toilet-technology-sanitation-water
**DAY 9 & 10:**

*Finalize Project:* Utilize what you have learned throughout this unit to develop ideas to answer the question “What can we do as individuals to help everyone on Earth have access to clean drinking water?” Consult project rubric for project expectations. (*Hint: Days 6-8 of the PBL unit were meant to guide you to potential solutions to this question!)

Possible Ideas for Presentations include, but not limited to:

- Videos
- Models
- Proposals
- Prezi
- Powerpoint
- Glogster
- Animoto
- Facebook Pages
- Visual.ly
- Easel.ly
- Documentaries
- Anything else approved by teacher
- Wiki

**DAY 11:**

*Present:* Present your solution(s) to the problem being addressed… “What can we do as individuals to help everyone on Earth have access to clean drinking water?”
Name: __________________                         Date: ____________

Water: PBL Project Task Guideline (Think Locally)

**TASK GUIDELINE (THINK LOCALLY)**

**DAY 6:**

*Assigning different roles for team members:* Each student will have a different role/responsibility within the group. See roles/responsibilities on ‘PBL Job Assignments’ handout…

*Review/Organize:* Review all materials handed out and discuss scope of work and expectations as a class and group with teacher.

*Team checklist:* Use this ‘PBL Checklist’ as a guide to keep your team on track and communicate with each other on the progress your team is making. Team will check off each line on each step when complete and the teacher will initial below each checkmark with approval so that the team may continue on to the next step.

*Build Background Knowledge of Problem:* There are a few websites you will want to explore as a team before you get started on your concept map (next step). Take this first day and explore each website to review information or build off what you have already learned (this should take you the remainder of the period, there is a lot of information to explore on these websites!).

http://water.usgs.gov/edu/
http://www.fewresources.org/water-scarcity-issues-were-running-out-of-water.html
http://water.org/water-crisis/water-sanitation-facts/

*Begin when ready!:* Review and begin filling in Concept Map when ready!
PROBLEM: Not everyone has access to clean water which is essential for life.

CAUSE: Growing Population, fixed amount of water supply

EFFECT #1: ____________________________

EFFECT #2: ____________________________

EFFECT #3: ____________________________

LOCAL SOLUTION: (What can we do as a community to solve or help the problem?)

IDEAS: Local Conservation Methods (i.e. School, Business)?

IDEAS: Hydrofracking?

IDEAS: Any others?
DAY 7:

*School Water Use:* How can we reduce water usage at school? See ‘Day 7 School Water Usage’ handout for further clarification.

@**Make a model of your design:** Take your idea(s) from the School Water Use activity a step further and make a model, showing how your idea would work (ex. Drawing, 3-D model, etc).

@**Persuasive Letter:** After your investigation, you may individually write a formal business letter to the principal of the school. In this letter you will identify two proposals for improving water usage at our school based on the team’s investigation and supporting research. Your letter must follow the conventions of a formal business letter and include an introductory paragraph that explains why responsible water usage is important, a body that thoroughly explains your ideas for improvement, and a closing that summarizes your ideas and thanks the principal for her time. See the example provided in the handout entitled ‘Day 7 Persuasive Letter Example’.
Water: Day 7 School Water Usage

School Water Usage: In this activity, you will investigate the school’s water usage through interviews, observations, and research. You may use the website below in your research to help figure out ways to cut the water usage of the school. Use the questions below to aid in your note taking during your investigation.


FOCUS AREAS – You will need to coordinate with school custodians, maintenance crew, cafeteria staff, teachers, etc. in order to obtain information in the following areas: storm drainage, gardens & athletic fields (watering), school showers, drinking fountains, restrooms, cafeteria, cleaning, etc.! Create a list of questions in these areas BEFORE your interview to make the most of your time.

REFLECTION QUESTIONS:

1) According to your research, where does your school use the most water?

2) In what ways can the school reduce water usage in this area?

3) In what ways is your school making efforts to cut water usage?

4) Can students do anything to help in reducing the school’s water usage?

6) Which results surprised you the most in this activity? Explain why.
**Water: Day 7 School Water Usage**

**Directions:** Propose 3 ideas to help limit the water usage at your school. Use the chart below to help you organize your thoughts for improving water usage.

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<tr>
<th>Wasteful Water Usage</th>
<th>Idea for Improvement</th>
<th>Effect of Implementation</th>
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</thead>
<tbody>
<tr>
<td>1) Running Faucets</td>
<td>1) Timer on Faucets</td>
<td>1) Reduce water usage</td>
</tr>
<tr>
<td>2) Athletic Field sprinklers</td>
<td>2) Install Turf</td>
<td>2) Reduce water usage, Reduce maintenance</td>
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</table>
Dear Dr. MacPherson:

It is common knowledge that 75% of the earth’s surface is covered in water and that the earth contains more water than any other planet in the solar system. But what is less known about the earth’s water resources is that of 326 million trillion gallons of water on earth, only .000036% of that is available for human consumption. Over 97% of the earth’s water is salt water found in the world’s oceans. This salt water, although important, is far too salty to be used by humans for drinking or washing. Of the 3% left, a good portion of it is buried so far beneath the earth’s surface that it is too costly to recover and be used by humans. The small percentage that remains is all we have to draw on for all our water related needs. SUNY Brockport being such a large community places a large demand on Western New York’s limited water resources, and should therefore do its best to consume water in the most responsible manner possible. The following paragraphs outline some economically feasible suggestions for improving SUNY Brockport’s current water usage.

The SUNY Brockport campus has over 30 buildings that are all quite large in size. When the square footage of roof space is combined across all the rooftops on campus there is a very sizeable amount surface area catching rain water during precipitation events. Currently this water is caught by rooftop drainage systems and deposited directly into the campus storm water sewer system. I propose that we tap this flow of rain water before it dumps into the sewer system and store a portion of it for watering our landscaping on campus. We currently use a large amount of fresh municipal water to hydrate our lawns, trees, and shrubs around campus which could be replaced by free and recycled storm water. Because implementation of a rain water harvesting system would only involve connecting a storage tank to the pre-existing drainage system the costs of the system are minimal while the benefits are significant.

Not only can we improve our water usage here at Brockport through harvesting rainwater, but we can also simply limit our consumption. Our campus has hundreds of bathrooms, which are used constantly by thousands of students and faculty. The flushing of toilets and use of showers combine to produce millions of gallons of water being sent down the drain. I propose that we utilize low flow shower heads and toilets to reduce the amount of water consumed. A typical shower head uses twice the amount of water necessary for a thorough and enjoyable shower and typical toilets can use three to four times the amount of water necessary to effectively flush
waste. We should replace old shower heads and toilets with low flow models to reduce water usage and bills here on Brockport’s campus.

In summary, harvesting rain water and installing low flow plumbing are two positive steps towards creating an eco-friendly campus here at SUNY Brockport. Taking these actions would allow us to reduce our depletion of water resources while at the same time help us to conserve financial resources during a time of economic hardship. I would like to thank you for your time and consideration of such important issues.

Sincerely,

*Your name*
DAY 8:
* **Hydrofracking:** Will you allow hydrofracking in your community? See handout entitled ‘Day 8 Hydrofracking Decision’ for more information regarding this hypothetical situation.

@**Trade Offs:** Research some other topics regarding ‘risk vs. reward’ scenarios and ‘trade-offs’ that will need to be made concerning water. Find some examples of ‘trade-offs’ that may need to be made in the future regarding water. Produce a type of artwork (painting, collage, drawing, etc) showing the trade-off and write a 1 page reflection describing what is being represented in your work.

@**Investigate:** Investigate your local supermarket (i.e. Wegmans) to find out what happens to all of the left over perishable “fresh food” such as seafood, fruits and vegetables, etc. when it is not sold by expiration date? How does this relate to water conservation? Propose a solution by writing a letter to Wegmans, making a youtube video, prezi, etc. (use any method that will communicate the problem and solution to the problem!)
Name: ___________________  Date: ____________

Water: Day 8 Hydrofracking Decision

**Task:** You will need to vote ‘YES’ or ‘NO’ at a town board meeting to allow the practice of hydrofracking in your town.

**Background Info:** Your team comprises the town board, which is meeting to discuss a plan to allow hydrofracking in your community. The town is financially hurting, and is need of more businesses in the area to increase town funding. Historically, the town has always been small, and cut off from many commercial businesses, and prides itself on its beautiful lakes and landscapes. Farming is the predominant occupation in the town, and has been since its creation. Currently, a gas company has offered the town millions of dollars for needed renovations around town and to help the town escape financial troubles. In return, the town board must agree to let the gas company perform the practice of hydrofracking in certain areas around town. Landowners will also be paid significantly for allowing this practice on their owned lands. The town board meeting is in 1 month, and you need to do some research to find out which way you will vote or try to persuade other members of the board (‘YES’ for allowing hydrofracking, or ‘NO’ for not allowing it in your town). As in any decision, you make a list of pros and cons for allowing this practice before you make any decision for or against it.

<table>
<thead>
<tr>
<th>PROS (For Hydrofracking)</th>
<th>CONS (Against Hydrofracking)</th>
</tr>
</thead>
</table>

Vote (Circle one) and justify your vote

**WILL YOU VOTE TO APPROVE HYDROFRACKING IN YOUR TOWN?**

- **YES**
- **NO**

Justification to board members:
DAYS 9 & 10:
*Finalize Project: Utilize what you have learned throughout this unit to develop ideas to answer the question “What can we do as a community to help everyone on Earth have access to clean drinking water?” Consult project rubric for project expectations. (*Hint: Days 6-8 of the PBL unit were meant to guide you to potential solutions to this question!)

Possible Ideas for Presentations include, but not limited to:
Videos
Models
Proposals
Prezi
Powerpoint
Glogster
Animoto
Facebook Pages
Visual.ly
Easel.ly
Documentaries
Anything else approved by teacher
Wiki

DAY 11:
*Present: Present your solution(s) to the problem being addressed…“What can we do as a community to help everyone on Earth have access to clean drinking water?”
DAY 6:
*Assigning different roles for team members: Each student will have a different role/responsibility within the group. See roles/responsibilities on ‘PBL Job Assignments’ handout…

*Review/Organize: Review all materials handed out and discuss scope of work and expectations as a class and group with teacher.

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   http://www.fewresources.org/water-scarcity-issues-were-running-out-of-water.html
   http://water.org/water-crisis/water-sanitation-facts/

*Begin when ready!: Review and begin filling in Concept Map when ready!
‘Think Globally’ Concept Map: Let’s organize our ideas…

**PROBLEM:** Not everyone has access to clean water which is essential for life.

**CAUSE:** Growing Population, fixed amount of water supply

**EFFECT #1:**

**EFFECT #2:**

**EFFECT #3:**

**GLOBAL SOLUTION:** (What can we do as a planet to solve or help the problem?)

**IDEAS:**

**IDEAS:**

**IDEAS:**
Name: __________________ Date: ____________

Water: PBL Project Task Guideline (Think Globally)

**DAYS 7-10:**
*Webquest:* Complete the webquest on the handout entitled ‘Day 7 Webquest’.

^**Interesting facts:** Pick 3 facts that surprised you the most on this list. Make a personal connection to the facts you picked by explaining how the fact could effect you personally in a poem, written reflection, or other literary form.


@**New Technologies:** Investigate what new technologies are being made available to 3rd world countries to develop safer drinking and sanitary conditions. Write a 1 page reflection on if you feel this new technology will be effective and be sure to justify your claim. Here is a link to a possible topic… [http://e360.yale.edu/feature/how_no-flush_toilets_can_help_make_a_healthier_world/2581/](http://e360.yale.edu/feature/how_no-flush_toilets_can_help_make_a_healthier_world/2581/)

@**Experiment:** Try this experiment (in URL below) outside of class time! Utilize Vernier Lab equipment in class and methods explained in video below to see if you can clarify the water (turbidity). Write up your lab procedure and results.

[https://www.youtube.com/watch?v=XF0DNdYASKM](https://www.youtube.com/watch?v=XF0DNdYASKM)

**DAY 11:**
*Present:* Present your solution(s) to the problem being addressed…“What can we do as a global community to help everyone on Earth have access to clean drinking water?”
Are we in the midst of a global water crisis?

A webquest investigating the importance of water on the living environment and the factors involved in keeping the water cycle in balance

Designed by:

Mr. Battle
INTRODUCTION

Clean **drinking water** is essential to the living environment. Access to safe drinking water has improved steadily and substantially over the last decades in almost every part of the world. However, some observers have estimated that by the year 2025 more than half of the **world population** will be facing water-based vulnerability. A recent report (November 2009) suggests that by 2030, in some developing regions of the world, water demand will exceed supply by 50%! Water covers 70.9% of the **Earth**'s surface. With the majority of our planet being covered with water, how is it that there is even debate of a possible water crisis?

PURPOSE

The purpose of this webquest is to educate you on one of the most vital natural resources we have on Earth, water. Not only will you gain information on the implications that water has on Earth, but you will also be able to learn to collaborate with a partner, and use multiple forms of technology in researching and presenting on a specific topic. These tools will help you prepare for higher education, employment opportunities, and general life skills outside of school and work. After completing this webquest, you should have a very good understanding of the term “water crisis” and the associated factors that contribute to this global problem. You will use your recently acquired knowledge to complete a digital project to teach others about this very important issue by giving a short presentation (3-5 minute) to the class on your final digital project.

TASK

*Create a digital project to show the importance of water in our lives and the factors that are contributing to a potential water crisis in the near future.* In this webquest, you and a partner will create a digital project (powerpoint, prezi, webpage, video, blog, on-line journal, wiki, etc.) that will represent your findings from the following tasks… (1) Investigate the importance of water to the living environment by understanding the process of the hydrologic cycle and what effects the balance of this cycle (both natural and human-induced changes); (2) You will then use your acquired knowledge of water to research and understand the potential water crisis and it’s impact on our environment; (3) Once you understand the specific problems that make up the potential water crisis, you will choose to focus your research on one of these specific problems and provide an in-depth analysis on that particular problem; (4) You will then summarize and reflect on what you have learned from this webquest; (5) Finally, you will present your digital project to your classmates in a presentation.
These tasks are more specifically defined in the steps outlined below for this webquest. Specific webpages are given throughout the steps outlined in this webquest. These webpages are to guide you through your research only, and they may or may not be used depending on how you wish to proceed with your research. Whichever resources you choose to use, be sure that the resource is credible and to reference your source somewhere in your project.

**STEPS**

STEP 1: Collaborate with your team to find out which tasks will be completed by whom. This is an important step in this project; *delegating tasks in an efficient way, as well as continuous communication with your team will help you to complete this project in a timelier manner*. Remember, not only will you be evaluated by your teacher for this assignment, but by your team members, so please share the work equally to get the grade you desire. Next, briefly read over all of the steps below before you begin to get a general idea of what you will be doing and the time this webquest will require. Lastly, look at the rubric to find out the expectations for this webquest. Keep these expectations in mind as you proceed from step to step in creating your final digital project.

STEP 2: Log onto the internet to explore the importance of water as a resource to the living environment. Take organized, meaningful notes *(You will be graded in part on the depth and organization of your notes)* on any research you find that answers the questions asked in this webquest or any facts you think are important to the completion of this webquest. The following link is an extremely useful resource to complete the tasks below… *http://ga.water.usgs.gov/edu/index.html*. Spend **at least** 10 minutes on this website to get familiar with what it has to offer and to complete the tasks below.

1- **Why is water important to life? What do humans use it for (be specific in answering this question, it will help you later)?**

2- **Explain processes involved in how humans acquire water & how these processes work in conjunction with the water cycle. *(i.e. What methods are used by humans to obtain drinking water? How do we know water is “clean”? How does water “replenish” itself from human use?)*

STEP 3: Now that you are familiar with how water is circulated through the hydrologic cycle and methods humans use to extract water for drinking and other uses, you shall move on to the issue of our potential global water crisis. Take organized, meaningful notes *(You will be graded in part on the depth and*
organization of your notes) on any research you find that answers the questions asked in this webquest or any facts you think are important to the completion of this webquest. The following website may be beneficial in researching the definition and problems associated with the water crisis included in the tasks below… http://water.org/water-crisis/water-sanitation-facts/. Spend at least 10 minutes on this website to get familiar with all it has to offer and to complete the tasks below.

1- What is the water crisis? (define it and explain it)
2- What specific problems constitute the water crisis?
3- Are the problems that constitute the water crisis caused naturally, caused by human influences, or caused by both? Explain.
4- After you have completed this research, do you think we are currently in a water crisis? Defend your position by explaining why you think we are/are not in a water crisis.

STEP 4: Now that you know more about the water crisis and the individual problems that are causing the potential for a water crisis, focus on one of the specific problems that are part of the water crisis. Depending on which individual problem you decide to focus on, the following websites may be of some help… http://thewaterproject.org/water_scarcity.asp, http://water.org/learn-about-the-water-crisis/facts/, www.google.com/, www.yahoo.com/. Spend at least 10 minutes on these websites to get the required information you need to complete the tasks below. Take organized, meaningful notes (You will be graded in part on the depth and organization of your notes) on any research you find that answers the questions asked in this webquest or any facts you think are important to the completion of this webquest.

1- Why did you pick this particular problem? (Do you feel it is the most important? Needs to be addressed first? Most interested in this problem?)
2- How & why is this a problem?
3- What has been done thus far in an effort to control or solve this problem? Has it worked (no success, limited success, great success?)
4- In your opinion, what may be done, either in addition or in replacement of, what is currently being done to control or solve this problem.
5- Give an example of where this problem has recently occurred that has been in the news currently (within the past year).

STEP 5: At this point, you have acquired a lot of information from various websites concerning multiple topics. These topics include; the importance of water on the living environment, the water cycle, the processes used by humans to extract water for use, the water crisis, the individual problems that contribute to the water
crisis, and an in-depth look at one of these individual problems. If you have not
done so along the way, organize your notes into a useful, meaningful, and legible
manner so that someone besides you (i.e. your teacher), can interpret them in an
accurate way. After you have done this submit these notes to your teacher for
approval to move on to the next step. **You may not proceed to the next step
until your teacher approves and initials your organized notes and informs you
to move on to STEP 6.**

STEP 6: You are now ready to focus on what you will be doing for your final
digital project. Communicate with your team and make sure you understand all of
the notes your group has organized (if you and your team have split up certain
aspects of the assignment, it is important that you understand both your notes and
your team member’s notes). After you and your team share a good understanding
of your group’s research, make an outline of what you plan on doing for your
digital project. Be sure to keep in mind the expectations listed in the rubric for this
project. Once this outline is complete, share with your teacher for his approval to
move onto the next step. **You may not proceed to the next step until your
teacher approves and initials your outline and informs you to move on to
STEP 7.**

STEP 7: You are now ready to create your final digital project. When you and
your team feel you have completed this project, be sure to check the rubric to make
sure you have adequately covered the expectations for this webquest.

STEP 8: Please reflect upon this webquest by answering the questions below.
*This step will be done individually by each person in the group and handed in
separately by each group member.* Each group member will provide a 1-3 page
paper (Times New Roman, 1-inch margins all around, double spaced) that answers
the questions below.

1) What have you learned as a result of this webquest?
2) What can we do as a global community to be a part of the solution to
the problem you have investigated?

STEP 9: Now that you are finished with your webquest, you and your team
should decide how you will give a brief presentation on your webquest (3-5 minute
presentation). Keep in mind, you are now the experts on the problem you have
researched. Because *you* are the experts, *you* will be teaching the class so that they
understand the problem as well as you understand it. HINT: Assume your
audience (the class) knows nothing about your topic! Here are some other things
to keep in mind as you build your presentation…
1) Start with an Introduction to your topic
   a) state what problem/issue your group studied
   b) why did you pick this topic?
   c) why is it a problem?
2) Methodology
   a) how did you delegate the work between you and your team?
   b) where did you find your information?
3) Results
   a) what did you find out on the problem?
4) Discussion
   a) what are some of the possible solutions to the problem you found in your research?
   b) what are some of your proposed solutions to the problem?
   c) what connections did you make to what you found in your research to your personal experiences with water/wastewater?

STEP 10: CONGRATULATIONS!!! You are now finished with your webquest. Please email me your completed project as a single file (.pdf, .ppt, etc.). If you cannot scan your webquest project as a single file to hand in, you may break it into 2 separate files to email to me. However, NO PROJECT SHOULD BE EMAILED TO ME IN MORE THAN 2 ATTACHED FILES, ANY EMAILS WITH MORE THAN 2 ATTACHMENTS WILL BE RETURNED!!!

CONCLUSION

By the end of the end of this webquest, you should have learned the following skills...
   - Practice working collaboratively
   - Independent research (finding information)
   - Computer skills
   - Organization
   - Time management
   - Gain knowledge about an important potential problem in our world
   - Use your knowledge to live a more responsible life in terms of sustainability for future generations.
WEBQUEST REFERENCES

http://ga.water.usgs.gov/edu/index.html

http://thewaterproject.org/water_scarcity.asp

http://water.org/learn-about-the-water-crisis/facts/
WEBQUEST GRADING RUBRIC

<table>
<thead>
<tr>
<th>TOPIC: ________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE</td>
</tr>
<tr>
<td>3 (Excellent)</td>
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<tr>
<td>0 (Unattempted)</td>
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<tr>
<td>NOTES (25%)</td>
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<tr>
<td>CONNECTIONS (25%)</td>
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<td></td>
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<tr>
<td>DIGITAL PROJECT GRADE:</td>
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<tr>
<td>DIGITAL PROJECT GRADE %:</td>
</tr>
<tr>
<td>TEACHER COMMENTS:</td>
</tr>
</tbody>
</table>
DAY 11 - WATER: Presentations

Lesson Objective(s): The learners will present potential solutions to the water crisis from different perspectives (individually, locally, and globally).

Purpose: The purpose of this lesson is for students to teach their peers what they have learned regarding the water crisis and what can be done at a specific level to help control this crisis.

Explain: Teacher used direct instruction at beginning of unit to give all students an opportunity to have adequate background knowledge concerning the water cycle, and the effects a growing population could have on the demands of the water cycle.

Guided Practice: All students had opportunities throughout the unit to utilize teacher feedback during different experiments in an effort to learn about the water cycle and current water crisis.

(Elaborate/Extend): Students have become the teachers in this day’s lesson, as they present their findings along with their opinions to demonstrate solutions at different levels to fixing the water crisis on Earth.

Assessment (Evaluate): Teacher uses PBL Rubric to assess students understanding of topic(s) regarding water cycle and water crisis.

Adaptations within the Inclusive Classroom: In this lesson plan, all students are assessed according to their abilities and contributions to the group. Students who performed extra assignments are given opportunities to present based on the additional work, and students who took on less challenging roles were expected to contribute in that capacity. In the end, all students contributed in different ways to the outcome of this project.
CLASSWORK/HOMEWORK

**Directions:** Answer the following questions with the most appropriate answer from what you have learned during this PBL assignment. The questions are not in order because they were taken straight off old Earth Science Regents examinations!

9. When snow cover on the land melts, the water will most likely become surface runoff if the land surface is
   (1) frozen  
   (2) porous  
   (3) grass covered  
   (4) unconsolidated gravel

4. Flash flooding is most likely to occur when heavy rain falls on
   (1) deforested landscapes with clay soils  
   (2) deforested landscapes with sandy soils  
   (3) forested landscapes with clay soils  
   (4) forested landscapes with sandy soils
21. The cross sections below represent three beakers that were used to test porosity. Beakers A, B, and C each contain a different size of bead. Each beaker holds an equal volume of beads. The amount of water needed to fill the total pore space between the beads in each beaker was measured.

![Beakers A, B, and C with different sizes of beads](image)

Which statement best describes the porosity that was found for these three samples?

1. A had a greater porosity than B and C.
2. B had a greater porosity than A and C.
3. C had a greater porosity than A and B.
4. All three samples had the same porosity.

22. Which graph best indicates the general relationship between soil particle size and the amount of water retention by a permeable soil?

![Graphs showing different relationships between particle size and water retention](image)

7. Which processes are most likely to cause a rise in the water table?

1. runoff and erosion
2. precipitation and infiltration
3. deposition and burial
4. solidification and condensation
10 Which two processes lead to cloud formation in rising air?
   (1) compressing and cooling
   (2) compressing and warming
   (3) expanding and cooling
   (4) expanding and warming

21 During a rainstorm, when soil becomes saturated, the amount of infiltration
   (1) decreases and runoff decreases
   (2) decreases and runoff increases
   (3) increases and runoff decreases
   (4) increases and runoff increases

8 Sediment samples A through D below have the same volume and packing, but contain different percentages of various particle sizes.

   Sample A: 75% clay and 25% silt
   Sample B: 25% clay and 75% sand
   Sample C: 50% pebbles and 50% sand
   Sample D: 50% pebbles and 50% cobbles

Which sample most likely has the greatest permeability?
   (1) A
   (2) B
   (3) C
   (4) D
DAY 12 - WATER: Reflection

Lesson Objective(s): The learners will reflect on the learning process, how they built off their prior knowledge of water, and the relevance of everything they learned throughout this unit.

Purpose: The purpose of this lesson for students to reflect on the learning process throughout the unit. The students will self-reflect on how they learned, as well as evaluate classmates to figure out ways they could have learned and worked together more efficiently. Lastly, the students will reflect on why learning the scientific content is more important than simply earning a grade for completing a project.

Explain: The teacher discusses the grading results for each team based on the rubric. Teacher explains how to fill out the ‘Self Reflection’ and ‘Peer Evaluation’ forms for additional grades.

Guided Practice: Teacher reviews answers to the regents questions with students and clarifies any misconceptions in connecting ideas from PBL project to answering multiple choice questions.

(Elaborate/Extend): Class discussion on the importance of awareness and knowledge pertaining to water, the most precious natural resource on Earth. Reflect on presentations and the importance of applying the knowledge learned throughout this unit.

Assessment (Evaluate): Teacher assess the student responses from regents questions to ensure students can make the connection from the PBL project to a multiple choice format in demonstrating understanding of the topic(s).
<table>
<thead>
<tr>
<th>PBL Rubric: Water</th>
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<tbody>
<tr>
<td><strong>1</strong></td>
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<tr>
<td><strong>Organization</strong></td>
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<td><strong>Teamwork</strong></td>
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<td><strong>Quality of Information</strong></td>
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<td><strong>Effort</strong></td>
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<td><strong>Proposal</strong></td>
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</table>
PBL Project Group Peer Evaluation Form (Confidential)

Your Name

Team Name:__________
Period:__________
Problem Assignment

Carefully evaluate the performance of each member of your group, excluding yourself, over the period of the group project.

5 – Outstanding 4 – Good 3 – Satisfactory 2 – Poor 1 – Unacceptable

<table>
<thead>
<tr>
<th>Item</th>
<th>Group Member #1 Name:</th>
<th>Group Member #2 Name:</th>
<th>Group Member #3 Name:</th>
<th>Group Member #4 Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did his/her fair share of the work that was required</td>
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<td>2. Cooperated with other group members</td>
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<td>3. Shared responsibilities and did not try to take charge inappropriately</td>
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<td>4. Completed his/her share of the work on schedule</td>
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<td>5. Always submitted his/her best effort</td>
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<tr>
<td>6. Communicated thoughts and feelings effectively</td>
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<td>7. Was always well prepared for meetings and the actual presentation.</td>
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<td>8. Participated in, and contributed to, all relevant discussions</td>
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<tr>
<td>9. Attended group meetings when required to do so</td>
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<tr>
<td>10. I would choose this person, over all others, to be in the same group with me in the future.</td>
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The average for this person (1 to 5): __________  __________  __________  __________  __________

(Round average for each group member to two decimal places, e.g. 4.25)

Use the back of this form for any additional comments you would like to make.

SELF REFLECTION GRADE

TEAM NAME: ____________________
TEAM MEMBERS: _______________________________________________________

Please rate your contribution to the group and evaluate the group on a scale from 1 – 5 with 5 being the highest.

INDIVIDUAL EVALUATION: Name__________________________________________

___1. Following teacher’s instructions ___6. Asking for help when needed
___2. Asking meaningful questions ___7. Sharing responsibilities
___3. Contributing ideas and information ___8. Respecting others
___4. Helping the group stay on task ___9. Explaining things to others
___5. Contributing materials ___10. Doing things on time

I could improve on_____________________________________________________________________.

I rank my contributions to the group as__________because__________________________________

___________________________________________________________________________________.

GROUP EVALUATION:

___1. Following teacher’s instructions ___6. Respecting others
___2. Asking meaningful questions ___7. Explaining things to others
___3. Contributing ideas and information ___8. Solving problems within the group
___4. Staying on task and meeting deadlines ___9. Consistent effort
___5. Sharing responsibilities ___10. Producing a quality product

I rank our group’s efforts at working together as_____because____________________________

___________________________________________________________________________________.

References


Gebbels, S., Evans, S., Murphy, L. (2010). Making science special for pupils with learning difficulties, British Journal of Special Education 37(3). DOI: 10.1111/j.1467-8578.2010.00463.x


