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Utilizing Problem-Based Learning Activities in Science with Students with Disabilities

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Utilizing Problem-Based Learning Activities in Science with Students with Disabilities

By

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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
Utilizing Problem-Based Learning Activities in Science with Students with Disabilities

By

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Acknowledgement

This thesis is dedicated to my mother, a devoted teacher who inspired me, encouraged me to pursue my dreams, provided me with unconditional love and support and ultimately influenced me to be the teacher that I am today.
Abstract

Today, science teachers are faced with a challenge: to provide an authentic and engaging science curriculum to an increasingly diverse population of students including students with disabilities. Furthermore, the challenge is compounded when teachers are asked to incorporate the new Common Core Learning Standards into their science curriculum. Because of these challenges science teachers may struggle to provide an authentic and engaging science curriculum and ultimately may find themselves resorting to lectures and “cookie cutter” lab activities. This thesis will offer support through the use of strategies and scaffolds to general and special education teachers who teach or consult in the science classroom. The unit provided within will utilized pre-developed case studies that have been adapted, modified, or enhanced to include supports and scaffolds for students with disabilities. The ultimate goal of this project is to provide a sample unit which incorporates problem-based learning case studies and the use of scaffolds to provide all students with an access to an authentic and engaging science curriculum.
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Chapter One: Introduction

Rationale:

All students should have access to an authentic science curriculum which will actively involve them doing science and ultimately result in the necessary learning needed to achieve current state science standards along with the more recent Common Core Learning Standards. Benjamin Franklin once said “Tell me and I will forget. Teach me and I remember. Involve me and I will learn” (Franklin accessed May 2014). This ancient yet famous quote could not be more correct and could not hit closer to home. As schools are seeing an increase in students with disabilities in the general education classroom, some teachers may be uncertain as to how to implement an authentic science curriculum when faced with a diverse population of learners. With the implementation of the Common Core and “No Child Left Behind,” teachers are more inclined to teach “basic skills, factual material, and formulaic writing” (Preus 2012) with the hopes that the students will pass the test at the end. Unfortunately this style of teaching does not provide an authentic learning experience and isn’t likely to benefit all students.

According to Preus (2012), authentic learning promotes constructing knowledge, disciplined inquiry, and assignments of immediate value beyond school” (p. 60). Furthermore, “engaging students in high quality intellectual work has resulted in comparable positive outcomes for secondary students with and without disabilities” (p.60). Unfortunately the use of authentic instruction in the science classroom has yet to be fully implemented in all schools. More often than not traditional lecture based teaching methods are used for science instruction. The teacher lectures the information that students are required to learn and memorize. This traditional method of teaching represents the “bucket theory” in that students are empty buckets and teachers fill them with concepts that they need to know (Allen, Donham, & Bernhardt, 2011).
Students are expected to study and memorize the content and then recall the content for a comprehensive, usually high stakes test. This method works for very few students and certainly does not work well for students with learning disabilities, as noted by Watt, Therrien, Kaldenberg, & Taylor, 2013 when they state “the shift over the last decade from traditional textbook-based instruction in science to more of an inquiry-based approach has led to improved science education and increased inclusion for students with disabilities (p.41).” Furthermore, it was noted in a population of students in Hong Kong that “students learning through PBL have better retention when compared with peers taught using Hong Kong’s traditional style” of lecture based learning (Wong & Day, 2009). Lastly, “educational researchers have come to learn that best practices for instructing students with special needs are also very effective with general education students. Conversely, best practices for general education students are effective with students with special needs” (Spaulding & Flannagan, 2012, p. 6). Many students are classified as a student with a learning disability. They range in having difficulties in specific areas such as reading, writing or math to a variety of difficulties including difficulty with retention, and processing delays. Many students benefit when they are actively involved in what they are learning and opposed to being told the information they need to know.

A better approach to teaching science curriculum would be to select an authentic approach like problem-based learning, and design units based on the principles of Universal Design for Learning. According to Watt et al. (2013), “UDL is a framework that addresses the variability of learners in the classroom by promoting multiple means of representation, actions, expression, and engagement” (p.41). The combination of UDL and a variety of learning strategies or scaffolds can help to facilitate authentic science instruction for all students including those with disabilities. A variety of strategies and scaffolds have been suggested in the literature.
to help facilitate problem-based learning activities. However, despite these strategies there are very few studies that show the use of PBL activities with the use of scaffolds specifically for students with learning disabilities. Strategies and scaffolds that have been used in science with students with disabilities include: graphic organizers, mnemonic devices, focus placed on the “big ideas”, and the use of cooperative learning, just to name a few.

The goal of this project is to create a compilation of inclusive problem based learning activities that would offer an authentic learning experience for all students in a specific unit within the Living Environment curriculum. Research has shown that problem-based learning is a more authentic approach for learning and is quite different from traditional teaching methods in that it requires teachers to take a step back from being the expert who dispenses information to students and to become more of a guide and facilitator as students construct their own knowledge through collaboration and problem solving (Akçay, 2009).

**Significance of the Project**

While problem-based learning can provide a more authentic learning experience, there are several concerns for implementation in the classroom including lack of time (too much curriculum to cover), and the belief that lower achieving students have difficulty or are unable to engage in and benefit from such activities. Most research completed on problem-based learning focuses mainly on average and gifted students (Belland, Glazewski, & Ertmer, 2009). Other research has shown that student with disabilities can participate in problem-based learning activities when appropriate scaffolds and strategies are used and when teachers follow the approach of Universal Design for Learning (UDL) (Watt, Therrien, Kaldenberg, & Taylor, 2013).
The compilation of problem-based activities developed for this project will contain appropriate scaffolds, as noted in the research presented in the following literature review, including but not limited to, cooperative learning groups, designated roles for group members, graphic organizers, mnemonic devices, and focus on “big ideas” as opposed to specific facts. The incorporation of these scaffolds into problem-based activities will allow all students access to an authentic learning experience within the Living Environment curriculum.

The following will include two chapters, literature review and the project design. The literature review will provide a comprehensive look at current literature in the area of special education, science education and the use of problem-based learning with this specific population. The literature review will provided a variety of strategies and scaffolds to be used with students with disabilities in order to make their science experiences authentic in nature through the use of problem-based learning case studies. The project design will include previously designed case studies that have been adapted, re-structured and enhanced with scaffolds in order to make them accessible to all students included in the general education setting.
**Definition of Terms:**

CONSTRUCTIVIST LEARNING APPROACH: an approach based on the idea that students construct their own learning through meaningful activities.

PROBLEM BASED LEARNING: problem-based learning (PBL) is a student-centered pedagogy in which students learn about a subject through the experience of problem solving. Students learn both thinking strategies and domain knowledge.

INQUIRY BASED LEARNING: (IBL) inquiry-based learning describes approaches to learning that are based on the investigation of questions, scenarios or problems - often assisted by a facilitator. Inquirers will identify and research issues and questions to develop their knowledge or solutions.

“BUCKET THEORY”: a belief that if students are provided with the necessary foundational knowledge then they will be able to recall or retrieve that information to solve clinical problems found in clinical practice (Allen, Donham, & Bernhardt, 2011).

STUDENTS WITH DISABILITIES:(SWD) a broadly defined group of students with physical and/or mental impairments such as blindness or learning disabilities that might make it more difficult for them to do well on assessments without accommodations or adaptations.

COOPERATIVE LEARNING: cooperative learning is a form of active learning where students work together to perform specific tasks in a small group.

GRAPHIC ORGANIZER: is a communication tool that uses visual symbols to express knowledge, concepts, thoughts, or ideas, and the relationships between them.

SCAFFOLDS: a scaffold is a temporary framework that is put up for support and access to meaning and taken away as needed when the child secures control of success with a task.
HARD SCAFFOLDS: hard scaffolds refer to static tools that are developed to address student difficulties during the PBL activity. These hard scaffolds can be computer or pencil and paper supports such as worksheets.

SOFT SCAFFOLDS: soft scaffolds are referred to as the response from the teacher when a student has a specific need. Soft scaffolds include the tutor or PBL facilitator, and the development of collaborative problem solving groups.

UNIVERSAL DESIGN FOR LEARNING: is a set of principles for curriculum development that give all individuals equal opportunities to learn.
Chapter Two: Literature Review

Overview

Problem-based learning seems to be one of the latest “buzz” words in the field of science education. Problem-based learning is a form of authentic learning that is centered on a real life problem. This method of teaching science first originated in medical schools as a practical way of teaching clinical problems. More recently problem-based learning has been used in middle and high school science classrooms. The use of problem-based learning has been credited for providing students with an engaging yet authentic science learning experience. Problem-based learning is thought to enhance students learning by increasing retention, improving higher order thinking and problem solving skills, improving student collaboration in addition to strengthening students’ reading and writing skills. Problem-based learning has been primarily studied using average and gifted students and very few studies have looked at the effectiveness of problem-based learning among students with disabilities. Of those studies reviewed, all report positive effects of using problem-based learning with students with disabilities. The benefits seen with this population include: greater retention of content, increased collaboration with peers and less reliance on the teacher, and greater motivation to learn. Problem-based learning can be implemented with students with disabilities when appropriate scaffolds are incorporated into the problem-based learning activity. Some scaffolds that help to make problem-based learning accessible to all students is the use of cooperative learning, graphic organizers, mnemonic devices and focusing the content of the problem on the “big ideas” or major understandings.

With the increase in mainstreaming students with disabilities, teachers need to develop authentic science learning activities that are accessible to all students. Based on the research, it is necessary to develop and implement authentic science units including problem-based learning.
activities that are appropriate and able to meet the science needs of all students because all students should have access to an authentic science curriculum.

**Problem Based Learning**

Problem-based learning originated in medical school settings as early as 1950 and 1960; at this time the goal was to enhance students’ medical knowledge by presenting information in a way that was representative of what would be seen in clinical practice (Allen, Donham, & Bernhardt, 2011). Problem-based learning is now more widely used in college universities, high schools and even in middle schools.

Problem-based learning is a constructivist approach to learning that requires teachers to take a step back from being the expert who dispenses information to students and to become more of a guide and facilitator as students construct their own knowledge through collaboration and problem solving (Akçay, 2009). Problem-based learning is very different from traditional teaching practices in that it provides more authentic learning. Traditional learning is often characterized by the “bucket theory” which believes that if students are provided with the necessary foundational knowledge then they will be able to recall or retrieve that information to solve clinical problems found in clinical practice (Allen, Donham, & Bernhardt, 2011). This is commonly seen in traditional high school classrooms where teachers provide students with the necessary information and students are expected to retain it and recall it on unit and state assessments. Jonassen (2011) described PBL compared to traditional teaching approaches in the following:
“Traditional models of instruction assume that students must master content before applying what they have learned in order to solve a problem. Problem-based learning reverses that order and assumes that students will master content while solving a meaningful problem. The problem to be solved should be engaging, but should also address the curricular issues required by the curriculum” (p.101).

Through the use of problem-based learning activities, students will develop a more enriching and meaningful learning experience by “engaging students as stakeholders in a problem situation” and ultimately will “facilitate deeper levels of understanding” (Akçay, 2009).

A small study in Hong Kong compared the effectiveness of traditional style lecture methods with problem-based learning. The study specifically looked at the impact the different approaches had on student outcomes as measured by pre and post-test scores, which assessed comprehension and application of content. In addition, they looked at whether or not their approaches allowed for more sustained learning over time. In other words did one favor greater retention of content over time than the other? The results showed that students learn at least as well by PBL as by lecture based learning (LBL). In addition, students that participated in PBL activities performed significantly better on delayed-posttest assessments than their peers who were instructed by lecture based learning (Wong & Day, 2009). This suggests that PBL allows for greater retention of content knowledge. It is also suggested that since PBL relies heavily on constructivism and not just memorizing facts, students may develop a better conceptual understanding and ultimately allow for greater retention (Wong & Day, 2009).

Despite these findings, teachers may be hesitant to incorporate PBL into their science curriculum. Preus (2012) attributes this hesitation to the requirements of “No Child Left Behind.” Preus (2012) claims that the requirement to include all students including those with learning
disabilities to take high-stakes testing has “led to greater emphasis on basic skills, factual material, and formulaic writing” (p.59). Preus (2012) believes that emphasis needs to be corrected and suggests that students perform better on high stakes tests when teachers “engage them in high quality intellectual work rather than emphasizing basic skills and broad coverage of material” (p.60). When I ask my co-teacher if we could try implementing a PBL or inquiry based activity her response is “we don’t have enough time. We have too much content to get through before the Regents exam.” Unfortunately she is having difficulty seeing that meaningful learning is being sacrificed in order to cover a broad range of content.

Problem-based learning is one example of authentic instruction that has many positive effects on student learning with an increase in student engagement and improvement of student attitudes toward learning. Preus (2012) defines authentic instruction as “teaching that promotes constructing knowledge, disciplined inquiry, and assignments of immediate value beyond school (p.60). When students are engaged in their learning process and find the learning significant to their lives, they are more apt to find academic success. PBL also can help to strengthen academic skills in the area of reading, writing, research, thinking and teamwork skills (Allen, Donham, & Bernhardt, 2011). Cooperative learning groups help to foster teamwork and research skills, while writing skills are developed through the culminating product, which is usually in written form. These are skills that are vital and can help to facilitate lifelong learning (Allen, Donham, & Bernhardt, 2011). In addition to these skills, Akcay (2009) noted that students who engage in PBL activities will develop stronger problem solving skills and PBL will also allow them to confront any misconceptions they may have. Through authentic learning experiences, students are able to construct their own knowledge while combining school learning and real life scenarios. Students who participate in problem-based learning will become self-regulated
learners that engage in meaningful learning, which can then be transferable to other learning situations (Akçay, 2009).

**Problem-based learning in Special Education**

Despite the increase in mainstreaming there is very little research that suggests the use of problem-based learning or even inquiry learning with students with disabilities. Most studies focus on the use of problem-based learning with average and gifted students (Belland, Glazewski, & Ertmer, 2009) and save authentic learning experiences for “higher functioning students who have more background knowledge” (Preus, 2012). Teachers who have little experience with PBL and teach students with disabilities in the general education classroom may be hesitant to use PBL activities. Some may believe that students with disabilities are unable to complete such authentic learning activities and tend to reserve these kinds of activities for “higher functioning” students who have a more “solid knowledge base” (Preus, 2012). Others might believe that these students are unable to fulfill leadership roles in-group activities and therefore may serve as passive learners instead of as active learners (Kincaid 2006). Still others tend to stray away from authentic learning experiences like PBL because of high stakes testing which leads teachers to teaching to the test and focus on memorization and drilling (Savery, 2006). Savery (2006) presents the issue that there is not much time to allow for PBL when the day is structured around meeting state mandated curriculum.

However, research shows positive evidence that students with disabilities are able to participate or complete problem-based and inquiry based activities (Belland, Glazewski, & Ertmer, 2009; Kincaid & Jackson, 2006; Watt, Therrien, Kaldenberg, & Taylor, 2013). Kincaid and Jackson (2006) looked at a small group of students with a variety of disabilities. A PBL case
was developed based on students’ questions they asked about the cracked sidewalks that they had to wheel a classmate’s wheelchair over on a walk during gym class. The students wondered how they could fix the sidewalks so that their classmate could navigate the sidewalk easily. The teachers who designed a PBL case for the students found this experience to be empowering for their students. They noticed that students wanted to work together and wanted to help each other solve the problem. In addition, they saw an improvement in attendance, increase in positive attitudes and an increase in motivation to learn. In the end the students participating in this PBL scored above average on the rubric used to grade writing, problem solving and computer skills. Watt et al. (2013) noted that students with disabilities found success with PBL activities when they were provided with appropriate scaffolds. For example, Watt et al. (2013) describes a scenario where several students were having difficulty deciding where to start with their science investigation. The teacher provided these students with a mnemonic device for remembering the step for conducting scientific investigations. This was enough to steer students in the right direction. Lastly, Belland et al.(2009) made the claim that even though PBL is primarily used with average and gifted students, it can “positively influence motivation, social skills, peer acceptance and achievement among students with special needs” because of the cooperative learning aspect of PBL (Belland, Glazewski, & Ertmer, 2009).” In addition, it was noted that students with disabilities would benefit from PBL by strengthening their problem solving skills while also helping them become more self-directed and less reliant on the teacher. In this study, they show one successful example that one student classified with a learning disability and ADHD found success in a PBL activity. The student was placed with two general education students and while all students had difficulty getting started with the activity, they were one of the few groups to come up with a solution to the problem and they were able to justify it by
participating in a debate. During this case scenario, the student took a role in the group as the task performer, relied less on his teacher and more on his classmates, reported that he would like to complete another PBL and ultimately participated in the debate in front of his classmates. The student reported that the PBL activity helped him improve self-confidence especially when standing up and talking in front of others (Belland, Glazewski, & Ertmer, 2009). Lastly, Preus (2012) looked at whether or not students with disabilities would benefit from authentic learning activities. This particular study noted that authentic learning methods were possible to use in inclusive settings. The outcomes of the study indicated that students without disabilities tended to do better than those with disabilities when using authentic learning activities. However the study pointed out that students with disabilities were held to the same high expectations and were able to complete the same challenging tasks as their peers (Preus, 2012). In conclusion, students with disabilities can benefit from PBL by developing their problem solving skills, team-work and collaboration skills, and increase in self-confidence and also become more self-directed learners.

Making PBL Meaningful in Special Education

It was noted that problem-based learning activities can be used with students with disabilities when appropriate scaffolds/strategies are used and when teachers follow the approach of Universal Design for Learning (UDL). According to Watt et al. (2013), “UDL is a framework that addresses the variability of learners in the classroom by promoting multiple means of representation, actions, expression, and engagement” (p.41). Furthermore, Dieker et al. (2013), explains that the main principle behind UDL is that “all materials, activities, and assessments should be accessible to all and should allow students to learn and be assessed based upon their strengths, not their weaknesses” (p.20). Basham and Marino (2013), notes that students with disabilities tend to struggle with the STEM (science, technology, engineering and math)
curriculum resulting in very few students with disabilities pursuing STEM careers. Basham and Marino (2013) also favor the use of Universal Design of Learning to help these students gain access to STEM curriculum. They stress the importance of intentional planning to meet the variability of students within the STEM classroom. This research suggests the need for general education and special education teachers to work closely together when designing science lessons centered on problem-based learning or inquiry learning in order to meet the needs of all students at various learning levels and learning styles.

Several pieces of literature stress this importance of collaboration between both general education teachers and special education teachers. The general education teacher may develop the problem based learning activity and the special education teacher can advise strategies that will help support all students in finding success in PBL learning (Watt, Therrien, Kaldenberg, & Taylor, 2013). A second piece of literature noted another aspect of collaboration that helped to address the challenges of students with disabilities in a STEM learning environment. In this literature the teacher team (general education teachers and special education teacher) viewed the challenge of making inquiry-based activities accessible to all students in an inquiry-based problem. They welcomed these challenges and collaborated with each other to come up with a way to solve the problem. These teachers noted that being flexible and focusing on the needs of the students was critical in working through the challenges they faced (Bargerhoff, 2013). Dieker et al. (2013) suggested co-teachers focus on five areas: teaming, reading, writing, cooperative learning/disciplining and assessment. Specialists leading professional development for this teacher team believed that focusing on these five areas would allow for the two teachers to collaboratively meet the needs of their students while having high academic and behavior objectives, which would ultimately help to strengthen their co-teaching relationship (Dieker,
Finnegan, Grillo, & Garland, 2013). Through the use of co-teaching and collaboration, two teachers with different specialties will be able to develop strategies and scaffolds to help facilitate the use of problem-based learning or inquiry based learning with students with disabilities.

In summary, research encourages the use of collaboration between general and special education teachers. General education teachers can present the PBL and special education teachers can help to scaffold or adapt the PBL to meet the needs of all students. Having dual certification in science and special education, I will develop and scaffold some PBL’s so that they are appropriate for all students while adapting others so that all students can find success in the activities.

**Strategies and scaffolds to help facilitate PBL and IL with students with disabilities**

A variety of strategies and scaffolds have been suggested in the literature to help facilitate PBL activities. A scaffold can be defined as a temporary framework that is put up for support and access to meaning and taken away as needed when the child secures control of success with a task. Just like a new building under construction, it is important to remember that scaffolds are “temporary” and they should be gradually taken away once the student becomes confident with the process. Scaffolds should not be viewed as a crutch but viewed as a support system to help students develop independence with complex science problems. However, despite these strategies there are very few studies that show the use of PBL activities with the use of scaffolds specifically for students with learning disabilities. Despite this, it has been more recently noted by Spaulding & Flannagan (2012), that “best practices for teaching students with special needs, educational researchers have come to learn that best practices for instructing students with special
needs are also very effective with general education students. Conversely, best practices for general education students are effective with students with special needs (Spaulding & Flannagan, 2012, p. 6).

According to Ferreira, problem-based learning starts with a problem that can be “teacher or student generated, connected to the personal experiences of the students, and includes independent and critical thinking opportunities” (Ferreira & Trudel, 2012). Furthermore, in order for problem-based learning to be effective, there needs to be a shift in pedagogical practice from teacher centered to student centered and the teacher needs to be comfortable serving as a facilitator instead of the expert (Ferreira & Trudel, 2012). In addition, Azer et al. (2012) advises that when developing PBL units, the units should be centered on specific learning goals, and should include an engaging “trigger” or hook. A trigger or hook could essentially be an experience students can relate to and therefore would foster student discussion. Azer et al. (2012) describes a good PBL trigger as: addressing key components of the case, highlight’s key problems, addresses background information about the case and is ultimately a realistic scenario. Lastly, when developing a PBL unit, it is important to keep your students’ needs in mind when structuring the case. Cases should be developed based on previously learned information in previous cases (Azer, Peterson, Guerrero, & Edgren, 2012). This might also mean that in some cases PBL’s may involve more open-ended inquiry where in other cases they may be more structured as in guided inquiry. The latter might be seen more, given the increase in inclusive education and mainstreaming.

Throughout literature, scaffolds have been described as being “soft” or “hard” scaffolds (Choo, Rotgans, Yew, & Schmidt, 2011; Simons & Klein, 2007). Soft scaffolds are referred to as the response from the teacher when a student has a specific need. Soft scaffolds include the tutor
or PBL facilitator, and the development of collaborative problem solving groups. In contrast, hard scaffolds refer to static tools that are developed to address student difficulties during the PBL activity. These hard scaffolds can be computer or pencil and paper supports such as worksheets. The worksheets would be designed to provide hints to the learner as to how to go about solving the presented problem (Choo, Rotgans, Yew, & Schmidt, 2011).

Some specific scaffolds and strategies that have been useful in helping students with disabilities achieve success with PBL activities include the use of cooperative learning groups and specific role identification. In cooperative learning groups, students work together in small groups to perform specifically assigned tasks. In some cases the teacher may assign specific roles to students to help facilitate student accountability. Some specific roles used by Hoppe (2014) include the role of director, secretary, time keeper and recorder. These specific strategies help to facilitate positive group interactions and also help to increase the self-confidence of students with disabilities when presenting information in front of their peers (Belland, Glazewski, & Ertmer, 2009). Furthermore, Spaulding & Flannagan (2012) commented on the benefits of using cooperative learning when they mentioned “by working with a peer or small group, they can be successful. From this successful experience students gain confidence along with conceptual understanding and, with sufficient repetition reinforcement, can begin to demonstrate the skill independently” (Spaulding & Flannagan, 2012, p. 7). This further supports the idea that scaffolds should only be temporary and ultimately guide students to develop independence with the skill. It was also noted that cooperative learning groups also help students with disabilities to rely more on each other for guidance in problem solving than relying on the support of their teacher (Belland, Glazewski, & Ertmer, 2009). In regards to students with disabilities, effective student grouping can help to teach social skills directly in the science classroom and can help improve
the attitude and achievement of diverse learners in the science classroom (Dieker, Finnegan, Grillo, & Garland, 2013). In one particular case study using college-aged students, the use of “soft scaffolds” (like a tutor or facilitator), and the dynamics of their PBL team were considered to have the most influence on student learning as compared to “hard scaffolds” like supplemental worksheets (Choo et al., 2011). Choo et al. (2011) describe the role of a tutor and facilitator as a person who would simply ensure that students were learning the content and progressing through the problem. They stressed that a tutor should have the content knowledge and also be able to manage groups of students (Choo et al., 2011). Yet, in a case study of middle school students, “hard scaffolds” provided in the form of hints, guiding questions and expertise for approaching the presented problem were found to improve academic success on some components of the task compared to those students who did not receive the scaffolds (Simons & Klein, 2007). These cases suggest that the use of cooperative learning groups or the use of a tutor can help to facilitate PBL activities in a way that has positive outcomes on student learning while some students may benefit from the use of “hard scaffolds” in the form of hints and guiding questions provided either as pencil and paper-based or computer-based.

Some teachers may be reluctant to use PBL or inquiry learning (IL) in their classroom because there might be an overwhelming concern about the “un-structured and open-endedness” of PBL. As a result some may find PBL and IL activities as ineffective teaching methods in the science classroom. Literature suggests otherwise. Hmelo-Silver et al. (2007) defends problem-based learning and inquiry learning as “powerful and effective models of learning” in response to Kirschner et al. (2006) who states that PBL and IL are classified as “minimally guided instruction” and therefore are ineffective approaches to learning (Hmelo-Silver, Duncan, & Chinn, 2007).”Like other researchers, Hmelo-Silver et al. (2007) find PBL and IL to be effective models
of learning especially when they use scaffolds. Hmelo-Silver et al. (2007) explain that the use of scaffolds can help to reduce “cognitive load” and “help students to acquire disciplinary ways of thinking and acting” (Hmelo-Silver, Duncan, & Chinn, 2007). Scaffolds suggested to facilitate PBL and IL included the use of questioning, coaching, modeling, and the providing of “expert information.” Other suggested scaffolds included the use of templates or forms for students to complete and fill in as they complete the learning activity (Hmelo-Silver, Duncan, & Chinn, 2007). One specific scaffold described by Hmelo-Silver et al. (2007) in order to reduce cognitive load, is to use a white board or other device for posting information about the case study, for organizing and monitoring their findings and posting their action plan. In doing this the group is able to see where they need to go and what they need to do to solve the problem. Posting of this information for the group to see, helps to develop a routine for moving through the activity and helps to establish group norms (Hmelo-Silver, Duncan, & Chinn, 2007). Reflective of the Universal Design for learning, Savery (2006) believes that any student new to PBL will require significant scaffolding to help support the development problem solving skills, self-directed learning skills and collaboration skills (Savery, 2006). This suggests that all students can benefit from the use of scaffolds until they reach a level where they are independent and the scaffolds can be reduced or removed completely.

In other literature, it is suggested that a well-structured and organized PBL could help facilitate the activity and help students to find success. This approach is similar to guided inquiry, in that students receive a little more guidance through the use of scaffolds and the organization of the case or problem. A PBL or an inquiry-based activity can be structured in a way using scaffolds that support learning for students with disabilities. Watt et al. provide a visual that depicts the continuum of inquiry-based activities. On one end of the continuum there is open-
ended inquiry, which uses very little structure. On the other end of the continuum is guided inquiry, which is more structured and utilizes scaffolding. In structured (guided) inquiry the teacher develops a problem for investigation; the teacher structures the investigation and provides feedback to students throughout the investigation. The teacher usually pre-teaches concepts prior to the inquiry activity and utilizes graphic organizers to support students throughout the process (Watt, Therrien, Kaldenberg, & Taylor, 2013). This method used to scaffold inquiry-based activities could easily be applied in PBL activities.

Other specific strategies noted by Watt et al. (2013) and Kaldenberg et al. (2011) include focusing on the “big ideas,” the use of mnemonic devices to help remind students of the steps involved in the scientific process and key vocabulary, and lastly, the use of graphic organizers. It should be noted that these two articles are different but are written by the same group of authors. First and foremost focusing on the “big ideas” or major concepts teachers want students to understand, when deciding what to teach in the science classroom will help to reduce the focus on memorization which is often difficult for students with disabilities (Watt, Therrien, Kaldenberg, & Taylor, 2013). Preus (2012) and Basham and Marino (2013) are in agreement that focusing on the “big ideas” is important for implementing authentic learning activities like problem-based learning. Basham and Marino (2013) define “big ideas” as “intended outcomes that interlink and provide conceptual and relational understanding to content” (Basham & Marino, 2013). Focusing on the “big ideas” allows teachers to design “a clear measurable instructional focus that disregards superfluous content and experience (Basham & Marino, 2013). When students are able to engage in hands on activities (PBL, IL, experimentation) that are focused on the big ideas they are more likely to develop an in-depth understanding of overall science concepts (Kaldernberg et al., 2011).
Other strategies noted in research by both Watt et al. (2013) and Kaldernber et al. (2011) recommend the use of mnemonics for helping students remember and retrieve newly learned concepts and vocabulary and the use of graphic organizers. Graphic organizers like concept maps help students to make connections between newly learned material and what they may already know. Graphic organizers provide a visual representation which can be helpful in the retention of newly learned science concepts (Watt, Therrien, Kaldenberg, & Taylor, 2013). Basham and Marino (2013) referenced the use of technology like Prezi for creating a graphic organizer that shows the relationships various concepts. Graphic organizers can benefit students with varying ability levels. Students with disabilities may need the use of a concept map to help them understand basic relationship among a sample of concepts and to help them see the big picture. Whereas a student who is viewed as gifted may present his understanding of the relationship among several complex concepts by utilizing a program like Prezi to demonstrate his understanding (Basham & Marino, 2013).

One additional scaffolding strategy similar to graphic organizers, noted by Spaulding & Flanagan (2012) is the use of “hint cards” for students who might be struggling in solving complex science problems. The hint cards provide a series of questions to help students think through the problem solving process in order to come up with a solution. In addition, students are provided with hints of what they might have seen during the lab activity and simple explanation of what their observations might mean. Students then complete a graphic organizer to summarize their understanding of the “big idea” presented in the lab activity (see attached image of hint card and graphic organizer in Appendix A) (Spaulding & Flanagan, 2012, pg. 11). Furthermore less widely researched strategies for scaffolding inquiry-based activities include, technology (specifically Netbooks for researching and recording), structured Web quests, and checklists for
explicit explanations as to what needs to be completed during the activity (Kincaid & Jackson, 2006).

When considering the use of problem-based learning among a population of students with diverse learning needs it is necessary to carefully plan and coordinate the use of scaffolds to help all students achieve the learning outcomes presented in PBL activities. Belland, Glazewski, & Richardson (2008) notes that an important component to PBL is formulating evidence based arguments to help justify students’ solutions and to explain why their solution is reasonable (p. 402-403). Belland, Glazewski, & Richardson (2008) propose several scaffolds that will help student with conceptual, metacognitive, procedural and strategic learning in order to assist students in developing evidence based arguments during PBL units (p. 407). Furthermore they suggest the scaffolds should be faded over time to “promote transfer of student skills in completing those tasks unaided in the future” (p.408). The types of scaffolds recommend to help with evidence based argumentation include the use of question prompts, expert modeling and concept mapping. The use of these scaffolds in conjunction with the previously mentioned scaffolds (graphic organizer, focus on the “big ideas” and mnemonic devices) provide a variety of scaffolds that could assist in facilitating PBL among students with disabilities. Question prompts assist by asking the student text questions there are concept or metacognitive based that assist the student in solving the problem. Expert modeling in this case uses video clips of experts demonstrating how to approach the problem. Lastly, concept mapping similar to graphic organizers, help students to form a visual representation of the problem (pg.408). These scaffolds when used correctly will help students to develop independence with the skill of developing evidence based arguments associated with PBL activities.
Implications

Overall it has been found that problem-based learning and inquiry learning have been noted for increasing student engagement, improving attitudes towards learning and helping to build students’ conceptual knowledge by focusing on the “big ideas” as oppose to strict memorization of facts. These methods of pedagogy have been primarily studied in average and high achieving or gifted student populations. In fact, very little research has been done to suggest the effectiveness of PBL and IL on the learning of students with disabilities. Of the studies found and presented in this literature review, all suggest that PBL and/or IL could be used with students with disabilities and improve student learning and student outcomes. Success among this population of students included increased participation/attendance, improved attitudes towards learning, less reliance on the teacher and greater communication among peers, increase in self-confidence, and satisfactory scores on assessments. Despite these findings there is still very little research that supports the use of authentic learning activities like problem-based learning.

When considering the use of PBL and/or IL activities collaboration with the general education and special education teacher should take place in order to identify strategies and scaffolds that will help to benefit all students (general education and special education students) when performing PBL and/or IL activities. When implementing PBL and/or IL within the STEM curriculum, it is advised that teachers utilize the Universal Design for Learning in order to address the variability among students and to differentiate learning activities. A wide variety of scaffolds both soft and hard have been noted to help students perform PBL and IL activities. Some of these scaffolds and strategies include cooperative learning, mnemonics, graphic organizers, focusing on the big ideas, questioning techniques and the use of an expert and/or tutor. Additionally, modeling and coaching have been suggested as possible scaffolds to use. Of
the scaffolds identified, cooperative learning, graphic organizers, mnemonics, and focusing on
the big ideas tend to be the most widely used and repeatedly mentioned scaffolds specifically
used with students with disabilities. It should still be noted that little research has been completed
with this population in using these presented scaffolds during PBL and IL activities.

The research provides support for use of PBL and IL over traditional lecture style
methods with students with disabilities but fails to provide adequate concrete evidence showing
appropriate scaffolds that will help to facilitate these activities. It would be wise for general and
special education teachers to work together when developing PBL and IL units to devise
appropriate strategies and scaffolds that will help all students to achieve the goals stated in the
unit. It is my goal to transform a standard lecture based curriculum into a more authentic learning
curriculum focusing on the use of problem-based learning. Using my science content knowledge,
my knowledge of pedagogy skills in the area of special education, and keeping in mind the
Universal Design for Learning, I plan to devise a unit within the Living Environment curriculum
that implements the use of PBL activities that are engaging and appropriate for both special
education and general education students.
Chapter Three: Project Design

Overview

This project is designed to include a compilation of inclusive problem-based learning activities that will offer an authentic learning experience for all students within the Living Environment curriculum. This compilation will focus on an Ecology unit specifically focusing on human impact. The problem-based activities will align with the current NYS Living Environment Content standards along with the NYS Common Core Learning standards. While meeting the high expectations of the NYS standards, these problem-based activities will contain strategies and scaffolds that will allow all students access to these activities. These project-based learning activities will follow a framework presented in one of my graduate classes and used by Professor Kathy Hoppe. The problem-based activities included in this unit will contain some pre-made PBL’s that are adapted to meet the needs of all students along with originally designed PBL’s developed using Kathy Hoppe’s framework. Each problem-based learning activity will help students to answer the essential questions and student learning objectives presented in the following unit: How will you choose to leave your mark? The impact humans can have on the environment.

Significance of the Project

This compilation of PBL activities will become increasingly handy as the number of students with disabilities in general education science classes increases. As special education laws encourages students to be placed in the least restrictive environment, general education
teachers are seeing an increase in students with disabilities placed in their classes. In conjunction, educations laws like “No Child Left Behind” places demands on teachers to ultimately prepare all of their students to pass high stakes tests that ultimately reflect teacher performance. Inadvertently these demands have influenced the way teacher present science curriculum. While authentic learning like problem-based learning activities have been the latest “buzz” in science education, it is still likely many science educators resort traditional methods where information is dispensed and the students are expected to practice and regurgitate the information for unit exams.

It is my goal to develop a compilation of PBL activities for a unit in the Living Environment curriculum that will benefit all students and will encourage general education teachers to move away from traditional teaching approaches and try inquiry based activities in their classroom. PBL and inquiry activities help to offer a more authentic learning experience which is more engaging and motivating for students. When students are actively involved in their learning they are more likely to find it meaningful and tend to retain what they have learned. It is my belief that this simple shift in teaching method will help to improve student learning and performance in the Living Environment curriculum.

My compilation of PBL activities will be unique in that the PBL activity would be organized in a way that helps guides students through the course of the problem all while promoting higher level thinking and problem solving skills. The presented problem or case study would be introduced in segments with guiding questions as opposed to being presented all at once upfront with one open ended question. Initially, each activity would be presented with a graphic organizer that presents the “big ideas” that students should take away from the experience. In addition, each activity would be used with in cooperative learning groups of
mixed ability groups. Each student would be provided a role to complete within the group. This style of group work helps to hold each individual accountable and will help prevent one or two students from doing all the work.

Through the combination of cooperative learning and various learning scaffolds like graphic organizers and focus on the “big ideas,” all students will be able access an authentic learning curriculum within the science classroom. As students become comfortable with the scaffolds provided within the PBL activities, scaffolds and strategies will gradually be faded out to further develop students’ critical thinking and problem solving skills.

### Project Outline

<table>
<thead>
<tr>
<th>Title of the case study</th>
<th>Approximate number of days of each case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Study: Water Quality</td>
<td>6, 55 minute class periods</td>
</tr>
<tr>
<td>Case Study: Air Pollution</td>
<td>6, 55 minute class periods</td>
</tr>
<tr>
<td>Case Study: Carbon Footprint</td>
<td>7, 55 minute class periods</td>
</tr>
<tr>
<td>Case Study: Global Warming</td>
<td>8, 55 minute class periods</td>
</tr>
<tr>
<td>Case Study: Alternative Energy</td>
<td>6, 55 minute class periods</td>
</tr>
<tr>
<td>Case Study: Invasive Species 1</td>
<td>5, 55 minute class periods</td>
</tr>
<tr>
<td>Case Study: Invasive Species 2</td>
<td>5, 55 minute class periods</td>
</tr>
</tbody>
</table>
Project Structure

Each case study in the compilation will include the following when applicable:

- **Grade level**
- **Topic/Case Study**
- **Time Period**
- **Overview**
- **Rational for use with students with disabilities**
- **NYS Living Environment Standards**
  - Standard 4/ Key idea7: Human decisions and activities have had a profound impact on the physical and living environment
- **Big Ideas**
  - Our environment has a limited number of resources and increase in population, societal decisions and technology can all place stress on the availability of these resources
  - All living things interact with one another and can alter the environment
  - The way in which we use our resources and interact within our environment is influenced by our attitudes, society’s attitudes and our culture
- **Essential Questions:**
  - In what ways do humans rely on the environment?
  - How does a change in human population and our lifestyle choices impact the availability of natural resources?
  - What factors influence changes in the physical environment and how do these factors facilitate these changes?
  - What factors influence humans use of environmental resources and how they interact with the environment?
  - What are some alternative ways to manage our resources to help create a more sustainable environment
- **Scaffolds used**
- **Notes for teacher implementation**
- **Materials and resources needed**
- **Specific unit activities and handouts:**
  - Problem-based learning case studies centered around Ecology with a strong emphasis on human impact

Each problem-based learning activity will start by identify the “big ideas” for the PBL case study/activity. Students will have a clear idea of what they should be able to do by the end of the activity. Each activity will start with a 2–3 part case study which will be disclosed throughout the activity or a single case scenario. Each activity will be structured as follows according to
Professor Hoppe’s “Basic Steps for Classroom PBL” accessed at http://sciencesupport.net/pblgen.htm.

Most case studies will follow a similar format as indicated below:

1. Present part 1 of the PBL case - read as a class assigning roles to different students
2. Students record facts and questions about the case
3. Students are divided up into their PBL groups (cooperative learning groups)
4. Student groups brainstorm a list of facts and questions
5. PBL groups conduct research related to the case
6. Read PBL part 2- read as a class assigning roles to different students
7. Groups record more facts and questions
8. Students complete an inquiry related lab activity pertaining to the case
9. Students report their findings using various methods for presentation

In addition each PBL activity, (specifically the inquiry based activity) will contain scaffolds and strategies to support all types of learners. The culminating unit will be accessible to special and general education science teachers and will be designed for implementation in and inclusive science classroom. The scaffolds should gradually be reduced through the unit as students become more comfortable with the problem based learning format. For this unit you will see the fading of scaffolds as students move through the case studies.

Case Study 1: Water Quality
Grade Level: 9th grade Living Environment/ Biology and/ or Environmental Science

Topic: Water Quality “The case of Bear Creek and the Belly-Up Trout”

Time Period: 6, 55 minute class periods- additional time may be necessary for the water quality sampling field trip

Overview:

In this PBL case study students will have to determine what is causing a population of trout to die along one portion of Bear Creek. Students will have to propose a solution for solving the problem. In this case study students gain a better understanding of water pollution and the impact it can have on the environment. Students will become familiar with water quality assessment techniques and will utilize water sampling kits to test the quality of the water of a local creek. The culminating assignment for this PBL will be a presentation stating the potential cause of the problem supported by evidence, and a probable solution for solving the problem.

Rationale:

From my experience of working with students with learning disabilities in the science classroom, I have come to learn that they struggle when given an open-ended problem that requires them to think independently and come up with a solution. I have also learned through administering learning style inventories, that most of my students with learning disabilities need and learn best through hands-on activities in conjunction with visual representations and authentic experiences such as those that allow students to be vested in the process. For example, this lesson focuses on the issue of water pollution and the negative effect it is having on a local fish population. Give my population of students; this is applicable to many of them as they enjoy fishing locally, making this an authentic experience for them.

This specific case study will provide an authentic “real life” scenario, along with hands on experience in water sampling, with content specific information being organized in the form of visual representations through the use of graphic organizers.

This specific case study is uniquely designed for students with learning disabilities because while it provides an authentic experience with no “right” answer making it “open-ended,” it is structured in such a way that will provide these students structure and strategies that will allow them to find success in solving these types of problems. Through the use of cooperative learning, guiding questions, and graphic organizers, students will be guided through a form of inquiry in which as a group they will propose a solution to presented problem. Students will create a presentation and present their findings to their classmates. All students will need to participate during the presentation. All students will be assessed based on their presentation and their participation in the presentation. Students will also rate each other on their level of participation in their cooperative learning groups. Students will also self-assess on their level of participation as well.

To start, the NYS Living Environment Standards will be altered to focus on “big ideas” centered on water pollution. This will help to minimize student frustration with learning “specific details” and the big ideas presented in this lesson will be incorporated into future lessons.
allowing further repetition and reinforcement of concepts, something that is critical for student learning with this specific population.

For this case study student learning will take place in small cooperative learning groups of four students. Student will be heterogeneously grouped to ensure group diversity in learning strengths and styles. Students will each be given a specific role to play within the group in order to ensure student accountability. The teacher will serve as the facilitator checking in with the progress of each group while also monitoring individual accountability. At the end of the lesson, student will evaluate their peers and each student will meet with the teacher to discuss their performance. The use of cooperative learning groups and role cards will provide students with disabilities a safe level of responsibility that will help to build their confidence in solving science problems.

Furthermore, this specific case study is structured in such a way that students will rarely have to ask “what do I do next?” The case, while open-ended in nature, guides the students through the process using general guiding steps in the form of a student handout as opposed to providing specific step by step instructions. There is a happy medium between the levels of guidance provided in this lesson. This specific lesson will use graphic organizer and Jigsaw groups to split up required research and reading into a more manageable activity. The reading is accessed online and students can choose to listen to the reading and follow along, simply by downloading an application for their Internet browser which will read the text to them. Students will then use their graphic organizers to identify important information as it pertains to the water pollution problem. Completion of the graphic organizers will serve as formative assessments throughout the cases study in order to check on student progress. This will allow the teacher to step in and clear up misconceptions should they arise.

Finally, students will engage in final project/presentation within their cooperative learning groups to demonstrate their understanding as opposed to a paper and pencil test which often requires the memorization of specific facts and concepts, something students with learning disabilities struggle with. Each student will have a role within the project and will be responsible for presenting a portion of the project to the class. All students, including those with disabilities will be held to the same grading standards. Students with disabilities may be provided with additional scaffolds, such as breaking down their specific task into more manageable parts, a common modification found on most student IEP’s specifically used when given a large long term project.

**Standards:**

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living
and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

“Big Ideas” to focus on:

This will help students to see the “big picture” and minimizes the need for memorization of specific facts. In addition to focusing on the “big ideas” I have noticed with my specific population of students that they need a purpose for reading in order focus their reading and to enhance their comprehension.

- What is water pollution?
- What are the different types of water pollution?
- What effect does water pollution have on the environment?
- How do humans play a role in contributing to water pollution?

Scaffolds used:

- Cooperative Learning Groups/Jigsaw groups: Heterogeneously grouped to ensure diversity in learning strengths.
- Role Cards- ensure accountability and responsibility for all group members
- Concept Mapping- helps to present “big ideas” of water pollution into a visual representation
- Hint card questions- provides questions to consider in order to scaffold the problems solving process
- Facts and Questions graphic organizer- helps students to organize and visual the current information that they have and the information that they still need to find.
- Water pollution summary graphic organizer- serves as a guided note sheet and reduces cognitive load
- Water quality graphic organizer- serves as a guided notes sheet and reduces cognitive load

Teacher notes for implementation:

Based on student need and prior knowledge, the teacher may wish introduce briefly the concept of water pollution and the various types. The teacher may wish to pre-teach vocabulary depending on student need. The teacher should introduce the water quality testing lab activity which will include a field trip to a local stream or creek in the area. Teacher will hand out permission slips and explain and introduce the equipment and kits to be used in water sampling.

For the case study itself, the teacher should carefully select heterogeneously grouped cooperative learning groups based on students’ needs and strengths. The teacher may choose to assign the student roles as opposed to allowing students to select their own role. Roles include: Director, secretary, recorder, and time-keeper.
The teacher should explain the expectations of the water quality PBL and review the student handout packet. The students should also be introduced to their final assessment for the PBL and the rubric should be provide and explained in detail.

Materials and resources needed:

- Cooperative learning groups of 4 students heterogeneously grouped
- Student Chromebooks or access to a computer for each student
- Handouts- Facts/Questions, water pollution graphic organizer, water quality assessment graphic organizer, field trip handout, roles and descriptions
- Presentation materials
- Presentation Rubric
- Participation Rubric
- Peer Assessment Rubric
Case Study 1: Quality “The case of Bear Creek and the Belly-Up Trout”

Day 1:

1. **Anticipatory set**: Used to engage and introduce students to the topic of water pollution
   Students watch a short YouTube Video on water pollution:
   https://www.youtube.com/watch?v=V_pzxeHhkcQ
   Students think about and answer the questions: Why is it important that we take care of our water supply? What are some ways in which our water becomes polluted? What are some ways we can prevent water pollution? Students respond using the Think-Pair-Share format. Students think on their own first and write down their ideas. Students then pair up with partner and compare their ideas. Finally all students should be prepared to share out as the teacher will “cold-call” to select students to share their responses. This method allows students time first to think on their own and then time to compare their ideas with a peer.

2. The teacher introduces the students to the PBL case study by addressing the “big ideas” and reviews the final assessment and grading rubrics to ensure that students understand lesson goals and how they will be evaluated (See student handout)

3. Students are placed into pre-determined cooperative learning groups (4 students each) and are assigned roles (See attached roles and descriptions) It is important to select groups so that they are heterogeneous in nature. In addition, it is important to have diverse learning styles as well as leadership qualities in all groups. For example, each group should have at least one student who is considered a “student leader”

4. Students log on to the computers and given the following link to visit:
   http://www.cotf.edu/ete/modules/waterq3/WQmain.html
   Students click on “Water Pollution” and read aloud the overview found here in their groups. The teacher should circulate to make sure all students are following along as they read. Students who have difficulty following along may be provide with an index card to guide them as they read
   http://www.cotf.edu/ete/modules/waterq3/WQpollution1.html

5. In their cooperative learning groups, each student will read on one of the following types of water pollution found at the above link: Acid Mine Drainage, Agriculture, Sewage and Dredging. Students are given a purpose for reading: To find and identify the main ideas about the above types of water pollution. Students complete a graphic organizer and share out with the rest of the group. Each student should have a complete graphic organizer to reference throughout the case. (See attached graphic organizer) Students who have difficulty with reading may choose to use head-phones and have their specific content read to them via the Google Ap. I Speech.

Day 2:

1. Students gather in their group and take turns reading aloud the Case Study found here:
   http://www.cotf.edu/ete/modules/waterq3/WQsituation.html
2. Students should independently record the facts, questions and “what we should do” independently on their graphic organizer (See attached graphic organizer)
3. Students brainstorm as a group the facts, questions and “what we should do” as a group to ensure that all members have a similar understanding of the problem.
4. The group then identifies and records the problem statement
5. Students continue to gather research and Jigsaw “Water quality assessment” and “Hydrosphere” http://www.cotf.edu/ete/modules/waterq3/WQmain.html

Jigsaw Water quality assessment/ Hydrosphere
- Overview and biological assessment
- Chemical Assessment
- Physical Assessment
- Hydrosphere

Students read or listen to their assigned sections focusing on finding the main ideas. Students record their notes in a graphic organizer and share out the important information about their selected reading. Students should be reminded that they should be looking for information that might help them solve the case. (See attached graphic organizer)

6. In their groups using their role cards, students work through the Wheeling Creek Case Study. Students should use their notes and refer back to the reading to help them determine what is polluting Site 5 and 79 found under the tab “Name that Pollutant”

Assessment:

All students should hand in their “facts and questions” handout as well as their completed graphic organizer. These tasks will be evaluated and taken into consideration when the teacher evaluates the student on participation.

Day 3:

1. Students take a field trip to a local stream to test and determine the water quality. In their cooperative learning groups, students use field test water sampling kits to determine the water quality of the stream in their school’s neighborhood. Students report findings and share out in a class discussion. The teacher should do a demonstration modeling how to use the water sampling kit prior to the water testing activity.

Day 4:

1. Students review the Bear Creek Data found here: http://www.cotf.edu/ete/modules/waterq3/WQbear1.html
2. Students review the case study, revisit their facts, questions and “What should we do” graphic organizer and add to their chart as needed.
3. Using the research they have conducted and their graphic organizers, students work together as a group to determine what is causing the trout to die in the specified section of Bear Creek. Students provide data to support their answer
4. The group then conducts additional research to propose a solution to the problem.
5. Students are provided a “hint card” providing them with probing questions to consider in their attempt to solve the problem. In addition students will receive a concept map to help them organize their evidence which will help them to determine the cause of the problem. (See attached “hint card” and concept map)
Day 5:

1. Students have the whole class period to develop their presentation using a PowerPoint, movie clip, Prezi, poster, brochure or another teacher approved modality.

Day 6:

1. Groups present their findings and provide feedback to their peers via a peer assessment (see attached rubric).
2. The teacher evaluates the presentations using the final assessment rubric (see attached rubric).
3. Teacher evaluates student participation over the course of 6 days using the participation rubric (see attached rubric).

Student Handout:

Step by step guidance helps to guide students with disabilities through the problem solving process without directly giving them the answer or solution to the problem, which is often common in “cookie cutter” lab activities. However, in most problem-based learning activities students are provided with an open-ended problem in which they have to come up with a solution either through research or by a method of inquiry. This method raises the bar in regards to cognitive load in requiring students to think more critically and independently. This can be challenging for students who are diagnosed with a learning disability and have difficulty understanding abstract concepts. The handout provided below, in conjunction with the use of cooperative learning groups, graphic organizers and simplified learning objectives focusing on the “big picture,” help to reduce the cognitive load and the overwhelming feeling that may come with problem solving.

This specific handout is different from most lab handouts in that it isn’t a recipe or “cookie cutter” lab that will lead students to the “right answer.” Instead, this handout serves as a “guide” or stepping stones throughout the problem solving experience. Students are provided with clear simple instructions of what is expected during each day of the case study. They are provided with a purpose for reading when they are required to find research to help narrow their focus. In addition, they are provided with graphic organizers to help guide their note taking process. Limited space on the graphic organizer encourages students to select only the most important information. Students with learning disabilities tend to have a hard time identifying what is important and will usually highlight or copy down large chunks of text. Providing a limited amount of space and a purpose for reading, will help increase students’ independence with the research process. Furthermore technology can be added in which any text can be read to the student online. This is a positive addition for students who struggle to read grade level text. They can feel more independent having the text read to them by a computer as opposed to having a teacher read to them.
Case Study 1: Student Worksheet

Living Environment
Class
Name:
Date:

Title: Water Quality “The case of Bear Creek and the Belly-Up Trout”

Day 1:

Video Discussion Think-Pair-Share: Watch the following YouTube video on water pollution and think about the following questions Record your thoughts below, and they share your ideas with your partner. Be ready to share your thoughts with the rest of the class.

- Why should we not take our water supply for granted?

- What are some ways in which water can become polluted?

- What are some things we can do to prevent water pollution?

Cooperative Learning Groups:

For this problem based learning activity, you will be working in cooperative learning groups and each student will have an assigned role. Your teacher will give you a card with your role on it.

Below are the following roles and their job descriptions:

Secretary: Record notes from posters, maintain accurate notes on group progress, and participate in brainstorming

Time Keeper: manage the groups use of time, politely let each partner know how much time they have left to complete their task, monitor the group’s ability to stay on task, participate in brainstorming

Director: Make sure all of the jobs are assigned in the group, try to make sure everyone gets a chance to speak during the brainstorming session, participate in brainstorming

Recorder: Label brainstorming posters “Facts and Questions,” record responses during brainstorming sessions, participate in brainstorming

Water Pollution PBL

1. Log on to the computers and visit the following link :http://www.cotf.edu/ete/modules/waterq3/WQmain.html
2. Click on “Water Pollution” and read the overview in your groups aloud http://www.cotf.edu/ete/modules/waterq3/WQpollution1.html
3. In your cooperative learning group, each student will read about one of the following types of water pollution found at the above link: Acid Mine Drainage, Agriculture,
Sewage and Dredging

Your topic to read about is: ____________________________________________

4. **Reading purpose**: Find and identify the main ideas about your assigned type of water pollution. Complete the attached graphic organizer and share out your findings with the rest of the group. Each student should have a complete graphic organizer when you are done.

**Day 2:**

1. Log on to the computers and go to
2. **Independently** read the case study and record facts and questions you have about the case
3. In your groups, work together to compile and record the groups’ facts and questions. The group recorder should record the facts and questions on chart paper
4. Based on your facts and questions, brainstorm as a group “what should be done” to help you solve this case.
5. As a group look at your facts, questions and “what should be done” columns discuss and record the problem statement on your chart paper.
6. Jigsaw Activity: In your groups divide up the following topics:
   - Overview and biological assessment
   - Chemical Assessment
   - Physical Assessment
   - Hydrosphere

   **Your assigned topic is:** ____________________

7. Each student should read and take notes on their topic using the attached graphic organizer. You may choose to listen to the reading by downloading the free application from the Google Chrome Store call “I Speech”
8. Once everyone has finished, gather back into your groups and discuss/ share your findings from your reading. Everyone should complete the note graphic organizer.
9. Next, work in your groups using your role cards to work through the Wheeling Creek Case Study found here: [http://www.cotf.edu/ete/modules/waterq3/WQstudy1.html](http://www.cotf.edu/ete/modules/waterq3/WQstudy1.html)

   Using your notes from your reading, you must find out what is polluting Site 5 and 79. Record your answers and evidence on the group’s chart paper

10. **Ticket out the door**: Complete the “check for understanding” assessment and turn it in before you leave class. This will help to identify any student misconceptions prior to taking the field trip on day 3.
Day 3:

1. Today we will be taking a field trip to a local stream to test the water quality found in the stream. You will work with a partner and will be provided with the necessary supplies to test the quality of water. You will need to create a data table to record your findings. Upon completion of water sampling, you will need to draw conclusions about the quality of water based on your finding and knowledge of accessing water quality. Record your findings and conclusions in your science lab journal.

Day 4:

1. Log on to the computers and go to the following link. Review the data on Bear Creek found here: http://www.cotf.edu/ete/modules/waterq3/WQbear1.html
2. Take turns re-reading the case study. Then as a group revisit your facts, questions and “What should we do” graphic organizer. At this point you should add any new information regarding the problem to your chart.
3. As a group, using your research and graphic organizers you now need write a proposal suggesting what your group believes is causing the trout to die in the specified section of Bear Creek. You must be specific in identifying your cause and provide evidence to support your response. Type your response and submit your proposal to your teacher for review.
4. Once your proposal is reviewed, the group may begin researching a solution to the problem. As a group you should type your proposed solution and then submit it to your teacher for feedback.
5. If you are having difficulty identifying the cause of the problem, you may wish to use the following “hint card” with questions to consider when attempting to solve the problem. You should also use the following concept map to help organize your ideas in developing a solution.
Hint Card
Ask yourself these questions to determine what is causing the trout to die in Bear Creek

<table>
<thead>
<tr>
<th>Question</th>
<th>What you might see</th>
<th>What is going on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the pollution caused by acid mine drainage?</td>
<td>Increase in acidity, a decrease in oxygen, bright orange colored water and stained rocks</td>
<td>Heaving metals and acidic water is being released from above or underground coal mines</td>
</tr>
<tr>
<td>Is the pollution caused by agriculture?</td>
<td>Increase in the level of nitrogen and phosphorus, increase growth in aquatic plants, decrease in the amount of dissolved oxygen, presence of fecal coliform</td>
<td>Pesticides, fertilizers and animal waste enter the stream by runoff. These can be quite toxic and have immediate health effects on the stream</td>
</tr>
<tr>
<td>Is the pollution caused by sewage?</td>
<td>Increase in nitrogen and phosphorous, decreased levels of dissolved oxygen, increased amount of fecal coliform, increase in water temperature, found in rural or urban communities</td>
<td>Poorly installed septic systems and storm water runoff carries waste products into local streams and rivers.</td>
</tr>
<tr>
<td>Is the pollution caused by dredging?</td>
<td>Large areas of rock removed, increased water velocity and turbidity, increase in water temperature and an increase in siltation</td>
<td>Removal of rocks from streams alter the stream environment causing an increase in velocity and a disruption of habitat for many aquatic animals</td>
</tr>
</tbody>
</table>
Concept Map: Organize your ideas to help determine a solution for your source of water pollution

Problem:

Cause of pollution:

Evidence:

Solution:

Alternative Solutions:
Day 5:

1. In your cooperative learning groups, using your research and proposals create a presentation to present to the class. Your presentation must include the cause or reason as to why the trout are dying Bear Creek. You must provide evidence to support your cause. Finally you must present your proposal for solution to this problem. Be sure to include alternative solutions to the problem as well. All group members must contribute to the presentation while performing their assigned cooperative learning group role. All group members must participate while presenting to the class.
2. Presentations may be in the form of: posters, movies, PowerPoint, Prezi etc.

Day 6:

1. Presentations
2. Evaluate group members participation
**Supplements:**
**Types of Water Pollution Graphic Organizer**

<table>
<thead>
<tr>
<th></th>
<th>Acid Mine Drainage</th>
<th>Agriculture</th>
<th>Sewage</th>
<th>Dredging</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is it?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Impact on the ecosystem</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>How is it measured or evaluated?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Observations that indicate that this pollution is occurring</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Facts and Questions

<table>
<thead>
<tr>
<th>Facts</th>
<th>Questions</th>
<th>What we should do</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Problem Statement** (Based on the case study, what are we trying to solve?):

---

49
**Water Quality Assessment**

Record important facts for each topic.

<table>
<thead>
<tr>
<th>Biological Assessment (Key Points)</th>
<th>Chemical Assessment (Key Points)</th>
<th>Physical Assessment (Key Points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro invertebrates:</td>
<td>pH:</td>
<td>Elevation and catchment area:</td>
</tr>
<tr>
<td>Alkalinity:</td>
<td></td>
<td>Stream order:</td>
</tr>
<tr>
<td>Hardness:</td>
<td></td>
<td>Forest Canopy:</td>
</tr>
<tr>
<td>Nitrates:</td>
<td></td>
<td>Width, depth and velocity:</td>
</tr>
<tr>
<td>Phosphate:</td>
<td></td>
<td>Rock size:</td>
</tr>
<tr>
<td>Dissolved oxygen:</td>
<td></td>
<td>Turbidity:</td>
</tr>
<tr>
<td>Fecal Coliform:</td>
<td></td>
<td>Total solids:</td>
</tr>
<tr>
<td>Conductivity and density:</td>
<td></td>
<td>Temperature:</td>
</tr>
</tbody>
</table>
Hydrosphere

Record important facts about each topic.

<table>
<thead>
<tr>
<th>Overview</th>
<th>Importance of clean freshwater</th>
<th>Studying the Hydrosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ticket out the Door Assessment**

- What is water pollution?

- What are the different types of water pollution?
  - Describe one specific type of water pollution identified in your research

- What effect does water pollution have on the environment?

- How do humans play a role in contributing to water pollution?
Case Study 2: Air Pollution

Grade Level: 9th grade Living Environment/ Biology and/ or Environmental Science

Topic: Air Pollution: How safe is the air around your school and why should students be concerned?

Time Period: 6, 55 minute class periods

Overview:

In this PBL case study students will have to determine the air quality surrounding their school, local community and nearby cities. Based on their findings, students will need to develop a presentation stating severity of the problem, present their findings from their research and propose a solution that is reasonable and achievable by local community members. Initially, students will read a variety USA Today articles that expose the poor air quality around our nation’s schools. Students will then explore a computer simulation titled “Tox Town” in order to learn more about air pollution, the types of air pollutants, how they can be exposed and the impact that it has on their health. Once students have a basic understanding of air pollution and its consequences students will use several websites to determine the air quality surrounding their school, local community and nearby cities. Students will also complete an inquiry based activity where they will test the air quality of different areas around their school. The culminating activity of this case study will require a presentation presented to the school’s administration and school board.

Rationale:

From my experience of working with students with learning disabilities in the science classroom, I have come to learn that they struggle when given an open-ended problem that requires them to think independently and come up with a solution. I have also learned through administering learning style inventories, that most of my students with learning disabilities need and learn best through hands-on activities in conjunction with visual representations and authentic experiences such as those that allow students to be vested in the process. This particular case study starts by engaging students in problem that they might actually believe does not affect them: air pollution. The compelling articles of real life scenarios will spark their interest and leave them wondering about the air quality at their school.

This specific case study will provide an authentic “real life” scenario, along with hands on experience in testing for air pollutants in and around their school, with content specific information being organized in the form of visual representations through the use of graphic organizers.

This case study is specifically designed to benefit students with learning disabilities because it is designed in such a way that allows the students to think independently about a problem while providing them with structures and supports that will help to scaffold them
through the problem solving process. For this specific case study, students will once again work in small cooperative learning groups with each student having a specific role in the group. This will help to foster a sense of responsibility and ownership for students who often may lack confidence in their ability to participate in group activities. This will help them to be active participants in the learning process.

To start students will be given the “big ideas” that they should come to understand from this case study. The “big ideas” will focus on student learning of the general concepts centered on air pollution and its consequences as opposed to specific details regarding air pollution. Half way through the case study, students will be assessed on big ideas in order to check for individual understanding of the presented content.

Throughout this case study students will be exposed to a variety of scaffolds to help them find success with the presented problem. Students will be presented with a graphic organizer for note taking to help focus students research and reading. In addition, students will be working in cooperative learning groups and each student will be held accountable for a specific role within the group. The use of cooperative learning groups and roles help to reduce cognitive load for students with disabilities all while holding them accountable for individual learning. In addition, students with disabilities will be provided with a student handout to guide them through the problems solving process without giving away the solution to the problem.

Standards:

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

Big Ideas:

- What is air pollution?
- What are the different types of pollutants that contribute to air pollution?
- What effect does air pollution have on the environment and on humans?
- How do humans play a role in contributing to air pollution?
What is the air quality like around your school?
What are some solutions to reduce air pollution?

Scaffolds Used:
- Cooperative Learning groups - heterogeneous grouping
- Assigned group member roles - allows for individual responsibility
- Graphic organizer for note taking
- Student handout - serves as a guide throughout the problem solving process.
- Facts and Questions graphic organizer - helps students to organize and visualize the current information that they have and the information that they still need to find.

Teacher Notes for implementations:

This case study addresses another environmental problem presented in the unit of Human Impact, air pollution. Teachers should address students’ prior knowledge in regards to the topic and may show a brief YouTube video or other video of their choosing to introduce the case study topic. Teachers may also choose to pre-teach key vocabulary prior to giving students the case study. Below you will find necessary materials and a day by day progression of the case study. In addition, you will find a student lab handout for all students, a pollutant graphic organizer and a guided case study handout to assist students with disabilities throughout the problem solving process.

Prior to starting this case study, you will want to assign the jigsaw articles based on students’ reading levels. In addition, you will want to create heterogeneous cooperative learning groups to be used throughout the case study.

Resources and materials needed:

Websites:
http://www.epa.gov/air/caa/peg/toxics.html
http://mrsoshouse.com/pbl/air.html

Materials:
- Lab handout
Lesson Plans:

Day 1:

1. **Engage:** “Toxic Air and America’s Schools”- Students will count off by 4’s. “1’s” will read article A, “2’s” will read article B, “3’s” will read article C and “4’s” will read article D. Students will read their article and record the following information: main idea/main problem of the article, facts and questions that they have. See graphic organizer for students with disabilities
   - A. Chemical found in air outside 15 schools
   - B. Health risks stack up for students near industrial plants
   - C. Air tests reveal elevated levels of toxics around schools
   - D. Possible air hazards rarely considered in plans for schools

2. After students have read their articles and completed their facts and questions about the article, students form new cooperative learning groups. Each group should have a student who was a 1, 2, 3 and 4.

3. In their new groups, students will report on the article that they read, and other students should take notes on the articles that they did not read.

4. Groups all come together and the teacher presents the authentic case study and explains what will be expected for the remainder of the case study. The teacher will explain the research component on air pollution through the use of “Tox Town,” research component on the air quality in the students’ local community, air sampling lab activity and final presentation of the problem and solution to the problem.

**Case Study:** President Barak Obama is calling for heightened attention regarding air quality around schools. He is asking that districts nationwide meet with an air quality consulting firm in their area to assess the air quality around their school and local community. Our superintendent Mr. /Mrs. (insert name here) has asked that the biology students here at (insert school name) assist with the preliminary study of the air quality in and around the school and nearby within a 60 mile radius. Our task is to conduct research on the quality of air in our area as well as conducting some air quality sampling around the school. Once we have collected our data on the problem, we will need to evaluate the extent of the problem and propose a possible solution. Mr. Mrs. (insert name here) is
as asking that we present our findings to the school board as well as the local air quality consulting group.

Day 2:

1. Review the case study, task and expectations with the students.
2. Students meet in their cooperative learning groups that they were assigned to on day one
3. Students are assigned roles within the group and reviews their role description
4. All students should work together to brainstorm facts, questions and the overall problem statement presented by the case study and articles that they read on the previous day
5. Students document facts, questions and problem statement on chart paper
6. Students begin the research portion on air pollution by exploring “Tox Town” located here: ToxTown students should focus on the “city” or “town” depending on where their school is located. After selecting either the city or town, students should focus on the “school” within the selected area to learn more about the pollutants that can be found in or around a school
7. All students should read and complete the graphic organizer “What is air pollution”

Day 3: Research Day

1. In their cooperative learning groups, students will research the air quality around their school, in their local community and in nearby cities. Students should compile their findings on a piece of chart paper. Students should identify local and regional minor and major polluters. See graphic organizer for organizing findings
   Students may use the following sites to help them out:
   - Air Now
   - Air Scorecard
   - Weather Bug
   - National Weather Service
   - Weather Channel
2. In their cooperative learning groups, students should research and brainstorm possible solutions to reducing air pollution.
3. All groups should come back together and share out their findings as a class. The teacher will facilitate the discussion and compile groups’ data into one chart. Teacher start a poster on possible solutions to reducing air pollution
4. Teacher reviews the “big ideas” surround the issue of air pollution
5. “Ticket Out the Door Assessment” What is air pollution?

Day 4: Lab activity adapted from nih.gov
1. Today students will assess the air quality of various locations around the school. Students should first hypothesize as to where they may find the greatest occurrence of particle matter.

2. The teacher will discuss with the students why they the areas they selected might have the greatest amount of particle matter. The teacher will pass out pictures of dust mites, dust and mold to give them an idea of what they may find.

3. Students will brainstorm a list of places where they will want to test the air quality in the school. Working in their cooperative learning groups, students will receive their lab kit and will set up an experiment in their selected location. Students will take three samples of data at their location.

4. Students collect their data and share out their findings with the rest of the class. Data is then compiled into a chart and student display the data in a bar graph. Students analyze their findings.

5. See attached student handout for more details. Student handout is adapted from nih.gov
Objective

In this experiment you will test the quality of air by measuring the number of particles from different locations.

Testable Question

How does the testing location (indoors or outdoors) affect the amount of particulate matter collected on the index card samples?

Materials

- Vaseline
- Three index cards (4x6) with a hole punched in a corner
- Three strings
- Three glass slides
- Permanent marker
- Heavy-duty tape
- A penny

Procedure

1. Tie a string through the hole in each card to make loops for hanging cards in chosen locations.
2. Using a permanent marker, trace the outline of a penny onto a glass slide in order to create your sample area.
3. Securely tape the edges of the slide to the center of one of your index cards.
4. Smear a thin layer of Vaseline on the sample area on the glass slide.
5. Repeat steps 2-4 for the remaining cards.
6. As a group, take your index cards to your chosen location and find three secure places to hang or place your cards for collecting your samples.
7. Leave your index card at its location until the next session (24hrs).
How Clean Is Your Air? Part 2

Name(s):                                                                                                   Date:

Objective
In this experiment you will test the quality of air by measuring the number of particles from different locations.

Testable Question
How does the testing location (indoors or outdoors) affect the amount of particulate matter collected on the index card samples?

Materials
Magnifying glass and/or microscope

Procedure
1. Carefully collect your index cards from their locations, making sure not to touch the Vaseline-covered sample area. Bring your index cards to your group’s workstation where you have either a magnifying glass or a microscope.
2. Carefully remove the glass slide from the Sample 1 index card. If using a microscope, hold the slide by the edges making sure not to touch the sample area, and place it under the microscope. If using a magnifying glass, carefully place the index card with the slide on a flat surface for examination.
3. Using either a microscope or a magnifying glass, count the number of particles in the sample size found inside the Vaseline-covered collection area. A particle is any speck on the slide. It may be dust, pollen, or some other type of matter. If using a microscope and the Vaseline-covered area does not fit within the microscope field, count the particles in the microscope field only.
4. Record the number of particles you counted in the How Clean Is Your Air? Lab Results Sheet data table. Make sure your location is labeled in the corresponding row of the table.
5. Repeat steps 2-4 for the remaining two samples collected by your group.
6. Compute the average number of particles collected from your samples.
7. After computing the average at your workstation, move to the next workstation and record the data for the three samples at that workstation. Compute the average. Repeat for each workstation in the room.
8. After completing your data table, construct a bar graph of the data using three locations: your group’s location and two other locations from the data table. Remember to label the axes on your graph.
Name(s):  

Date:  

Directions:

1. Record the number of particles you counted in the data table below. Make sure your locations are labeled in the corresponding rows of the table.

Title: ________________________________________________________________

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Sample 1 # of particles collected</th>
<th>Sample 2 # of particles collected</th>
<th>Sample 3 # of particles collected</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Locker Room</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

...
2. Complete a bar graph of your results

Title: ______________________________________________________________
3. Analyze the results collected from your samples. Answer the following questions:
   A. Which location had the most particulate matter over the same time period?

   B. Overall, did indoor air have more or less particulate matter than outdoor air? (if relevant)

   C. Describe the environmental conditions at each location (i.e., spring day, trees are blooming).

   D. What conclusions can you draw from your data?
How Clean Is Your Air? Lab Rubric

Name (S): _______________________________ Date: ___________________

Results - Data Table

1. Does your data table have a title? ___Yes ___No
2. Did you fill in all the boxes? ___Yes ___No
3. Did you calculate the average for each column? ___Yes ___No

Results - Graph

1. Does your graph have a title? ____Yes ____No
2. Does your graph have correct labels on the axes? _____Yes _____No
3. Are your data correctly plotted? _____Yes _____No
4. Did you include an appropriate key if necessary? _____Yes _____No

Data Analysis and Conclusions

1. Did you determine which location had the most particle matter? ____Yes ____No
2. Did you state whether the indoor air had more or less particle matter than the outdoor air? _____Yes _____No
3. Did you describe the environment conditions at each location (i.e., spring day, tree are blooming)? ____Yes ____No
4. Did you draw conclusions from your data? _____Yes _____No

This lab was accessed from:
Day 5: Work day on Presentation

1. In your cooperative learning groups, using your research and proposed solutions for reducing air pollution, create a presentation to present to the school board and visiting air quality consulting firm. Your presentation must include the root cause of the problem, the severity of the problem in our area and proposed solutions for correcting the problem. You may wish to make something creative to hand out to the audience to remind them of the importance of reducing air pollution. You must include evidence to justify the extent of the problem. Finally you must present your proposal for solution to this problem. Be sure to include alternative solutions to the problem as well. All group members must contribute to the presentation while performing their assigned cooperative learning group role. All group members must participate while presenting to the class.

2. Presentations may be in the form of: posters, movies, PowerPoint, Prezi etc.

Day 6: Presentation Day

1. Presentations
2. Evaluate group members participation
Case Study 2: Student Worksheet

Living Environment

Name: ___________________

Human Impact

Date: _____________________

Air Pollution: How safe is the air around your school?

Big ideas to focus on:

- What is air pollution?
- What are the different types of pollutants that contribute to air pollution?
- What effect does air pollution have on the environment and on humans?
- How do humans play a role in contributing to air pollution?
- What is the air quality like around your school?
- What are some solutions to reduce air pollution?

Day 1:

1. Read and take notes on your assigned article. My assigned article is: __________________________________________
2. Your reading purpose is to identify the main idea or the main problem stated in the article
3. Record your notes in the following graphic organizer

Title of the article: _______________________________________________________

<table>
<thead>
<tr>
<th>Main Ideas/Problem</th>
<th>Important facts from the article</th>
<th>Questions I still have</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Cooperative learning groups
For this problem based learning activity, you will be working in cooperative learning groups and each student will have an assigned role. Your teacher will give you a card with your role on it.

Below are the following roles and their job descriptions:
Secretary: Record notes from posters, maintain accurate notes on group progress, and participate in brainstorming
Time Keeper: manage the groups use of time, politely let each partner know how much time they have left to complete their task, monitor the group’s ability to stay on task, participate in brainstorming
Director: Make sure all of the jobs are assigned in the group, try to make sure everyone gets a chance to speak during the brainstorming session, participate in brainstorming
Recorder: Label brainstorming posters “Facts and Questions,” record responses during brainstorming sessions, participate in brainstorming

4. Gather into your assigned cooperative learning group and review your assigned role.
   Take turns reporting on the article you read. Share your main ideas, facts and questions with your group members.

5. While other group members are sharing be sure to take note using additional copies of the graphic organizer that you used to take notes on your article.

6. Case Study: Listen and follow along as the teacher presents the following case study:

   “President Barak Obama is calling for heightened attention regarding air quality around schools. He is asking that districts nationwide meet with an air quality consulting firm in their area to assess the air quality around their school and local community. Our superintendent Mr. /Mrs. (insert name here) has asked that the biology students here at (insert school name) assist with the preliminary study of the air quality in and around the
school and nearby within a 60 mile radius. Our task is to conduct research on the quality of air in our area as well as conducting some air quality sampling around the school. Once we have collected our data on the problem, we will need to evaluate the extent of the problem and propose a possible solution. Mr. /Mrs. (insert name here) is asking that we present our findings to the school board as well as the local air quality consulting group.

Task:
- Research the air quality around your school, community and neighboring towns
- Complete an air quality lab activity around your school
- Determine how bad the problem (air pollution) is in your area
- Propose solutions that individuals can take to reduce/prevent air pollution occurring in your area
- Organize your findings into a presentation
- Present your findings

Upcoming activities:
- Review case study and expectations
- Review cooperative learning groups roles
- Brainstorm facts, questions, and problems found within the articles
- Research air pollution using “Tox Town” and complete graphic organizer note sheet
- Research the air quality around your school, community and nearby towns within a 60 mile radius. Research possible solutions to the problem
- Ticket out the door assessment- *Review and be able to answer the big ideas*
- Lab activity
- Presentation work
- Present your findings

Do you have any questions??

Day 2:

1. Today we will start by reviewing the case study, task and expectations. If you are unsure about the assignment make sure to ask your questions at this time.

Remember these are the following components to the task:
- Research the air quality around your school, community and neighboring towns
- Complete an air quality lab activity around your school
- Determine how bad the problem (air pollution) is in your area
- Propose solutions that individuals can take to reduce/prevent air pollution occurring in your area
• Organize your findings into a presentation
• Present your findings

2. Meet in your cooperative learning groups from yesterday and review your assigned roles and role descriptions.

3. In your groups, work together to brainstorm facts, questions and the overall problem statement as presented by the case study and articles you read on the previous day. The recorder should write these down on the provided piece of chart paper.

4. Now you will start researching on the topic of air pollution. Go to “Tox Town” located here: ToxTown. Focus on either the “city” or “town” depending on where your school is located. Next, focus on the kinds of pollution found around the “school”.

5. Identify the pollutants commonly found in schools and complete the following graphic organizer “What is air pollution”

What Is Air Pollution? We get the oxygen we need by breathing air; it’s a natural thing. We don’t usually stop to think about what’s in the air. However, besides elements like oxygen and nitrogen, the air we breathe may also contain pollutants. Air pollution is a problem that affects life all over the world. For example, you saw the pollutants that were collected on the dirty air filter. We can see these pollutant particles once they have accumulated on the filter, but we do not always see them in the air.

There are many kinds of air pollutants. The Environmental Protection Agency (EPA) calculates the Air Quality Index (AQI) for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. Ozone and particle pollution (particulate matter) are two common pollutants found in many parts of the country.

Many human activities create air pollution. In turn, the pollution causes problems for the health of humans and other life on our planet. To slow down that process, we can learn about what causes poor air quality and how to protect our life on Earth.

Here is your chance to learn more about air pollution. Check out Tox Town at toxtown.nlm.nih.gov and investigate all the different things you can breathe and how they can affect you.
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Accessed from:
Day 3: Research Day

1. In your cooperative learning groups, you will research the air quality around your school, local community and in nearby cities. You should compile your findings on a piece of chart paper. Make sure to identify local and regional minor and major polluters. See graphic organizer for organizing findings

You may use the following sites to help them out:
- Air Now
- Air Scorecard
- Weather Bug
- National Weather Service
- Weather Channel

What is the air quality like anyway?

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<tr>
<th>Location</th>
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2. Next, in your cooperative learning groups, research and brainstorm possible solutions to reducing air pollution.
3. Now, all groups will come back together and share their findings as a class. Your teacher will lead the discussion and compile groups’ data into one chart. Your teacher will start a poster on possible solutions to reducing air pollution. Use these charts as a source of reference throughout the rest of the case study.

4. Your teacher will now review the “big ideas” that surround the issue of air pollution. Listen carefully because this will help you for your “Ticket Out the Door Assessment”

What is air pollution?

5. Complete the “Ticket Out the Door Assessment” What is air pollution?

Day 4: Lab activity (adapted from nih.gov)

1. Today you will look at the air quality of various locations around the school. You should first hypothesize as to where they may find the greatest occurrence of particle matter, a form of air pollution.

   **Hypothesis:**

   I think I will find the most particle matter in __________________________

   because______________________________________________________________.

2. Next, your teacher will discuss the areas you have selected and explain why those areas may have the greatest amount of particle matter. Carefully look at the pictures of dust, dust mites and mold that your teacher will show you. These are some examples of particle matter that you might see.

3. In your groups, brainstorm a list of places where you will want to test the air quality in the school. You will receive a lab kit and in your group you will set up an experiment in your selected location. Your group will need to collect three samples of data at your selected location.

4. Your teacher will give you a student lab handout. Follow the step by step procedure with your group members.

Day 5: Presentation work day

1. Today you will work in your cooperative learning groups to organize your information into a presentation
2. First, decide in your group how you want to present your information. You may make a video, poster, PowerPoint, brochure, and any other creative modality that you may wish to use.

3. Make sure to include the following in your presentation:
   - Problem being investigated
   - Extent of the problem in your community and in neighboring areas
   - Types/kinds of air pollution - use your graphic organizer
   - Solutions to the problem and ways to prevent further air pollution
   - Be creative and have visuals

**Day 6: Presentation day**

1. Today you will give your presentation. Everyone in the group must participate and speak. After watching the presentations, complete the participation rubric for your group members including yourself.
Supplemental Handouts

Ticket out the Door Assessment

Name: _______________________                                    Date: ________________

- What is air pollution?
- What are the different types of pollutants that contribute to air pollution?
- What effect does air pollution have on the environment and on humans?
- How do humans play a role in contributing to air pollution?
- What is the air quality like around your school/ community?
- What are some solutions to reduce air pollution?
What Is Air Pollution? We get the oxygen we need by breathing air; it’s a natural thing. We don’t usually stop to think about what’s in the air. However, besides elements like oxygen and nitrogen, the air we breathe may also contain pollutants. Air pollution is a problem that affects life all over the world. For example, you saw the pollutants that were collected on the dirty air filter. We can see these pollutant particles once they have accumulated on the filter, but we do not always see them in the air.

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Case Study 3: Carbon Footprint

Grade Level: 9th grade Living Environment/ Biology and/or Environmental Science

Topic: Carbon Footprint: How can we reduce our school’s carbon footprint?

Time Period: 7, 55 minute class periods

Overview:

In this PBL case study students will have to determine the carbon footprint of their school. Based on their findings, students will need to develop a presentation stating the size of the school’s carbon footprint and evidence to document the size of the problem. Based on this data, students will need to propose a variety of solutions to help reduce the school’s carbon footprint.

This case study will be mostly researched based and will include using a carbon footprint calculator, interviewing school grounds crew on energy usage, and student inspections of the school building and grounds. Based on their findings, students will then propose potential solutions to reduce the school’s carbon footprint. The culminating activity of this case study will require a presentation presented to the school board, school administration and grounds and maintenance crew.

Rationale:

From my experience of working with students with learning disabilities in the science classroom, I have come to learn that they struggle when given an open-ended problem that requires them to think independently and come up with a solution. I have also learned through administering learning style inventories, that most of my students with learning disabilities need and learn best through hands-on activities in conjunction with visual representations and authentic experiences such as those that allow students to be vested in the process. This particular case study starts by engaging students in a problem that they might not actually believe exists: a carbon footprint. Students might actually be hearing this phrase for the first time.

This specific case study will provide an authentic “real life” scenario, along with hands on experience for gathering information about their school’s carbon footprint. Students will administer questionnaires, conduct interviews, and inspect the school building looking for data to help them calculate the school’s carbon footprint. Students will then assess the degree of the problem and propose a variety of solutions. This case study is the 3rd case study within the Human Impact unit and the teacher may wish to begin reducing the number of scaffolds provided to students with disabilities to help foster independent problem solving. This case study is a little more open ended and allows for more flexibility than the previous two. This case study focuses primarily on active research and does not necessarily offer a step-by-step lab activity that can be helpful for students with disabilities. Since this case study uses mostly research, students will
continue to be grouped in cooperative learning groups and students will be provided with graphic organizers to help them organize their research.

This case study is specifically designed to benefit students with learning disabilities because it is designed in such a way that allows the students to think independently about a problem while providing them with structures and supports that will help to scaffold them through the problem solving process. For this specific case study, students will once again work in small cooperative learning groups with each student having a specific role in the group. This will help to foster a sense of responsibility and ownership for students who often may lack confidence in their ability to participate in group activities. This will help them to be active participants in the learning process.

To start students will be given the “big ideas” that they should come to understand from this case study. The “big ideas” will focus on student learning of the general concepts centered on the concept of the “carbon footprint” and its consequences. Half way through the case study students will be assessed on the big ideas in order to check for individual understanding of the presented content.

Throughout this case study students will be exposed to a variety of scaffolds to help them find success with the presented problem. Students will be presented with a graphic organizer for note taking to help focus students research and reading. In addition, students will be working in cooperative learning groups and each student will be held accountable for a specific role within the group. The use of cooperative learning groups and roles help to reduce cognitive load for students with disabilities all while holding them accountable for individual learning. In addition, students with disabilities will be provided with a student handout to guide them through the problems solving process without giving away the solution to the problem. The goal of the guided handout is to provide student with all the necessary resources so that they are more independent and less reliant on the teacher. For students who struggle with reading the teacher may wish to share the guided handout with students via Google Docs. The students can then open the handout on their Chromebook or computer and use their Google application I Speak to listen to the directions presented on the handout.

Standards:

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.
7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.  
7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

**Big Ideas:**

- What is meant by the term “Carbon Footprint”?
- What effect does your “Carbon Footprint” have on planet earth?
- What is carbon dioxide and what role does it play in our environment?
- Identify sources of carbon dioxide
- What are some ways in which we can reduce our “Carbon Footprint”?  

**Scaffolds Used:**

- Cooperative Learning groups
- Assigned group member roles
- Graphic organizer for note taking
- Student handout- serves as a guide throughout the problem solving process.

- Facts and Questions graphic organizer- helps students to organize and visual the current information that they have and the information that they still need to find.

**Teacher Notes for implementations:**

This case study addresses another environmental problem presented in the unit of Human Impact, the carbon footprint. Teachers should address students’ prior knowledge in regards to the topic and may show a brief YouTube video or other video of their choosing to introduce the case study topic. Teachers may also choose to pre-teach key vocabulary prior to giving students the case study. Below you will find necessary materials and a day by day progression of the case study. In addition, you will find a guided student handout for students with disabilities which will serve as a scaffold and resource to help guide them through the research and problem solving process. Finally, teachers can also find additional graphic organizers to help students navigate their way through the case study. Knowing your specific population you may choose to use specific graphic organizers with specific students. Some of your students may not need the support of the graphic organizers and deciding which ones to use and with who is up to the discretion of the teacher.

Prior to starting this case study, you will to create heterogeneous cooperative learning groups to be used throughout the case study. In addition, you will need to contact school
administration and grounds crew and schedule times for them to meet with your students as part of an interview process about the school’s energy use, and waste production. Lastly, this case study is centered around student research and therefore teachers may wish spend one day introducing students to research through the use of Google Scholar, Google, and district databases.

**Resources and materials needed:**

**Teacher resource websites:**

http://greenappleproject.com/pbl/sample/high-school this website provides the foundation for this case study and the graphic organizers presented in this case study have been adapted from this website

http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge/Materials.aspx This website provides plenty of teacher and student resources for calculating the school’s carbon footprint. You will want to visit “Audit Tool Kit” and “Classroom Carbon Calculator”

http://www.greenschools.net/form.php?modin=53 –Green schools quiz. How green is your school?

http://www.discovery.com/video-topics/other/what-you-need-to-know-carbon-footprint.htm

Videos can be found at this website to help introduce the concept of “carbon footprint”

**Student Research Links:**

http://www.epa.gov/climatechange/ghgemissions/gases/co2.html


**Materials:**

- Case Study
- Background information handout- See attached
- Classroom Audit Sheet- See attached
- Excel Audit Spread sheet- Provide Link
- Climate Action plan-See attached
- Additional Handouts: Facts and question, problem statement, problem map, decision making matrix implementing the solution
- Student guided handout
Lesson Plans:

Day 1:

1. Pose the following question to students: What is meant by the phrase “carbon footprint?” Have students complete a KWL chart indicating what they already know about the topic, and what they want to learn about the topic.

2. Have students watch the following video: http://www.discovery.com/video-topics/other/what-you-need-to-know-carbon-footprint.htm first video clip “Meet the Smiths”

3. Have students revisit their KWL sheet and fill in additional information. Discuss the video and the information students have filled in on their KWL charts. If students have any unanswered questions, make sure to post/write them on chart paper as a reminder to students that these are questions that they might come back to after reviewing the case study conducting research.

4. Introduce the case study that students will be working on:
Meet the Problem

Problem: Carbon Footprint

To the teacher: You may introduce your students to the problem by presenting the following as an email or letter from a school administrator. Tailor as needed for your class, filling in the blanks with the appropriate information. Provide a copy for each student to refer to throughout the problem-based learning process. See the Teacher Guide for more ideas on how to introduce a problem.

__________________________________________________________________________

Dear ____________________________ students:

(course title)

Like most organizations, our high school has a significant carbon footprint. Carbon footprint is a calculation of the amount of carbon dioxide emissions that a person or organization is responsible for. The footprint measures direct and indirect amounts of greenhouse gas emissions, which trap heat in the earth's atmosphere. Carbon dioxide emissions also lower the quality of the air we breathe and contribute to other forms of pollution.

The average American's annual carbon footprint is estimated to be 20 metric tons of carbon dioxide, which is equivalent to burning 11,144 pounds of coal. This is five times the global average per person. Because of the negative impact on the environment, we are looking for more ways to shrink our school's footprint. We cannot do this without the participation of students, faculty, and staff. So we are continuing our efforts by asking students for their input on how our school can reduce its carbon footprint.

[Our school district has received funding for this project through the State House Bill 251, which also requires the district to reduce its energy consumption and greenhouse gas emissions 20% by 2014. We hope to exceed this requirement and see an even larger reduction.] A panel will hear your ideas for shrinking our carbon footprint on ____________ .

(date of final presentation)

Sincerely,

(name of school administrator)

Additional ways to introduce the problem can be found here:
http://greenappleproject.com/pbl/sample/high-school

5. At this point students should move into their cooperative learning groups. Students should first review their assigned role and responsibilities. Next, students work on completing their Facts, Questions and What we should do next graphic organizer.

6. Once students have completed the facts/questions handout, they should work in their groups to define the problem statement. Students should use the following handout as a tool to help them define the problem.
Defining the Problem Statement

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

Accessed from:
http://greenappleproject.com/pbl/sample/high-school

Day 2:

1. Student groups come together to review the case study and compile their list of facts and questions and what to do next. The teacher should record these on the board/ chart paper. Students share out what steps they believe that should do next. The teacher offers the opportunity to interview administration, grounds committee as part of the research process.

2. Students start by taking the Green Schools Quiz here to see how green they think their school is: http://www.greenschools.net/form.php?modin=53

3. Students and teacher work together to schedule interview opportunities with administration and grounds crew

4. Students review the background information on the areas that will be auditing and audit forms found here: http://www.nwf.org/pdf/Cool-School-Challenge/ES_CoolSchoolChallenge-AuditKit_Final.pdf Students should divide sections and record the main ideas to share with the rest of their group members. Students should send a copy of the background information and audit forms to those they will be
interviewing and completing the energy audit with. The audit worksheets will provide students with the questions that they will need to ask during the interview. Some students may wish to develop their own questions to ask administration and grounds crew.

5. Lastly, students should take a brief walk through their school and identify a classroom that they would like to audit with the grounds crew/administration. Students should record observations that they notice when looking at classrooms. Students should look for the following: number of computers, specifications about lighting, opportunities for recycling, access to a sink, heating/cooling of the classroom etc.

**Day 3:**

1. Today students will complete their interview/audit with administration and the grounds crew. Students should take their background information, audit sheets, clipboard and visit the classroom they selected with administration and ground crew. Students may need to ask questions to the teacher whose classroom they are visiting. The teacher should make other teachers aware that students will be visiting various classrooms and potentially asking questions.

2. Once the audit forms are complete the students will calculate the carbon footprint of the classroom they audited using the calculator found here: [www.coolschoolchallenge.org](http://www.coolschoolchallenge.org)

3. All students come back together and the teacher facilitates a discussion based on what they found during the audit. Students draw conclusions and should complete the following problem map:
4. Students meet in their cooperative learning groups review the case study and begin to brainstorm possible solutions for shrinking their school’s carbon footprint.

Day 4

1. Today is a research day. Students should begin developing solutions to help shrink their school’s carbon footprint.
2. Students’ research possible solutions to the problem and students with disabilities may use the following graphic organizer to help them organize their ideas.
3. Students end the day by completing a “ticket out the door” assessment on the “big ideas”

**Ticket out the door**
- What is meant by the term “Carbon Footprint”?
- What effect does your “Carbon Footprint” have on planet earth?
• What is carbon dioxide and what role does it play in our environment?

• Identify sources of carbon dioxide.

• What are some ways in which we can reduce our “Carbon Footprint”?

Day 5:

1. Today is a presentation work day. The teacher should provide students with what is expected in their presentation by providing them with a rubric. All presentations should include the scope of the problem that they found in auditing a classroom in their school. Furthermore, students will need to include possible solutions to this problem and analyze the pros and cons to their solutions.

Day 6:

1. Today students will present their findings and action plan to the rest of the class, administration and grounds crew.

Day 7:

1. Finish presentations if necessary
2. Students complete participation rubrics for their peers
3. Teachers provide feedback to each group
4. Students work together to complete the following Implementing the Solution handout:
Implementing the Solution

1. Record the key points of the “master solution” compiled from all the presentations.

2. How will your group implement its part of the master solution? What do you need to apply the solution in real life?

3. What obstacles did you encounter while implementing the solution?

4. What adaptations were necessary?

5. How effective is the solution so far? How do you know?

6. What additional steps or new solutions will you use to reach the desired outcome?

Accessed from:
http://greenappleproject.com/pbl/sample/high-school

5. Students finish off by answering the following reflection
Reflective Response

1. Think back on the process of solving this problem. Describe how you responded to the problem and the problem-solving process.

2. What did you learn about course-related content?

3. What did you learn about learning and working in a group?

4. What questions or problems remain unanswered?

5. What actions do you plan to take based on what you learned?

Accessed from:
http://greenappleproject.com/pbl/sample/high-school
Case Study 3: Student Worksheet

Living Environment

Name: ___________________

Human Impact

Date: ___________________

Shrinking Our School’s Carbon Footprint

Big ideas to focus on:

- What is meant by the term “Carbon Footprint”?
- What effect does your “Carbon Footprint” have on planet earth?
- What is carbon dioxide and what role does it play in our environment?
- Identify sources of carbon dioxide
- What are some ways in which we can reduce our “Carbon Footprint”?

Day 1:

1. Answer the following essential question based on your prior knowledge:

What is meant by the phrase “carbon footprint?”

Directions: Complete the following KWL chart on the above essential questions

<table>
<thead>
<tr>
<th>What I already know about the “carbon footprint”</th>
<th>What I would like to know about the “carbon footprint”</th>
<th>What I have learned about the “carbon footprint”</th>
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2. Watch the following video clip “Meet the Smiths”: http://www.discovery.com/video-topics/other/what-you-need-to-know-carbon-footprint.htm

3. After watching the video go back to your KWL chart and fill in any additional information you may have received from the video.
4. Now you will discuss the video and information in your KWL charts with the rest of the class. Be prepared to share your findings.
5. Were all your questions answered? If you still have any unanswered questions write them in the space below. Be sure to share these with the rest of the class.

Unanswered Questions that I still have regarding the “Carbon Foot Print”

*Your questions should be answered by the end of the case study*

6. Meet your case study:

Dear ____________________ students:

course title

Like most organizations, our high school has a significant carbon footprint. Carbon footprint is a calculation of the amount of carbon dioxide emissions that a person or organization is responsible for. The footprint measures direct and indirect amounts of greenhouse gas emissions, which trap heat in the earth’s atmosphere. Carbon dioxide emissions also lower the quality of the air we breathe and contribute to other forms of pollution.

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date of final presentation

Sincerely,
7. Gather in your pre-assigned cooperative learning groups. Assign and review your roles within the group.
   My assigned role is: ___________________________ I will be responsible for doing the following:
   •
   •
   •
   •

8. Read the case study together as a group and complete the following Facts, Questions, and What we should do next graphic organizer.

Facts and Questions

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<tr>
<th>Facts</th>
<th>Questions</th>
<th>What we should do next</th>
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</table>
9. Next, in your groups you should compile your facts, questions and what we need to do next onto chart paper.
10. Now you will need to work as a group to define the problem statement. Use the handout below to help you formulate your problem statement.

   **Defining the Problem Statement**

   Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

   A. What is the overriding issue or problem?

   B. What are the conflicting conditions that a good solution must satisfy?

   C. Complete the following statement, summarizing your answers above. This is your problem statement.

   How can we (see A above)... in such a way that (see B above)...  

   Accessed from:  
   http://greenappleproject.com/pbl/sample/high-school  

**Day 2:**

1. Start by meeting with your group members and review the case study and your list of facts, questions and what you need to do next.

2. All groups will now come back together as one group. Your teacher will ask you to share some of your facts, questions, and what you need to do next, with the rest of the class. Have your graphic organizer ready to share out. Your teacher will offer you the opportunity to interview administration, grounds committee as part of the research process.
3. You are ready to start the research process! Start by taking the following quiz to see how green your school is: http://www.greenschools.net/form.php?modin=53

**What were your results? Record them here:**

4. Next discuss with your group mates and teacher to schedule an interview opportunity with administration and grounds crew.

**Our Interview with administration and grounds crew is on:**

__________________________________________________

5. In preparation for your interview your group will need to review the following background information on the areas you will be interviewing and auditing on. Directions: Divide up the background information among your group mates and read your section. You should record the most important points from your reading and be ready to share with the rest of your group.

**Classroom Audit**

Use the enclosed Classroom Audit form (or feel free to create your own!) to gather data about classroom electricity use, transportation, heating, and waste generation and recycling habits. To help get you started, review this background information on each of the categories you'll be auditing.

**Background information**

**Electricity** used by schools for lighting and powering computers, televisions and other devices contributes to emissions of carbon dioxide (CO2), a greenhouse gas. Reducing the amount of electricity used can help lower CO2 emissions. In this part of the Classroom Audit you'll take a look at how much energy is being used to light the classroom, power computers and other electrical devices, and also hunt for energy —vampires.

**LIGHTING**
Most classrooms are lit by overhead light panels, commonly equipped with 32-watt fluorescent bulbs. In conducting your audit, look for the number and type of bulbs powered by each light switch, as well as for any other lights that might be in the classroom (such as desk lamps). If you cannot find the wattage of the bulbs, use 32-watts as your default or check with your custodian. Also find out how many hours the lights are kept on during a typical school day.

**ENERGY “VAMPIRES”**

Lights aren’t the only devices that use electricity. Take a look around the classroom. In addition to classroom lights, what else is using electricity? Are there any computers, projectors or DVD/VCR players? Appliances suck up energy even when they are not being used which is why they are sometimes referred to as — energy vampires. Vampires include devices with digital clocks (like DVD players) or internal remote control sensors (like some televisions), which draw energy just from being plugged in. Reducing vampire loads is as easy as plugging the appliance into a power strip and then turning off the power strip when not in use. Because computers and other electronics are usually put to good use during school sessions, this exercise focuses only on what happens to electronic equipment after school hours to see how much energy is being wasted. In this part of the Classroom Audit, take an inventory of the different electric devices and find out whether they are left on in active mode overnight, put to sleep or turned completely off. Refer to the table below for a description of the different operating modes. If devices are plugged into a power strip, find out whether the power strips are actually turned off at the end of the day.

### COMMON OPERATING MODOES FOR ELECTRIC DEVICES

<table>
<thead>
<tr>
<th>MODE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Active”</td>
<td>Device is on and serving its primary function. (Example: a DVD player playing a movie, or a computer running a program.)</td>
</tr>
<tr>
<td>“Sleep/Standby”</td>
<td>Device is in low-power mode. (Example: DVD player is on but not playing a disc; computer is on but in power-save/sleep mode.)</td>
</tr>
<tr>
<td>“Off”</td>
<td>Device is turned off but still plugged in and ready for action. (Example: DVD player is turned off but could be activated by remote. Digital displays will be visible.)</td>
</tr>
<tr>
<td>“Power strip/ Unplugged”</td>
<td>Device is plugged into a power strip, which is turned off at the end of the day. Or - the electronic device is unplugged. (Example: DVD player is receiving NO power. Digital display is NOT on and cannot be activated by remote.)</td>
</tr>
</tbody>
</table>

**ELECTRICAL APPLIANCES**

*(OPTIONAL)*
During the school day, energy vampires and other appliances transform into useful tools to help you learn. Nonetheless, you might want to know how much energy they consume during active use. In conducting your audit, look for the wattage of each classroom appliance and estimate how many hours each day the device is on. If the wattage is not listed on the appliance, you can still estimate it by finding the current draw (in amperes) and multiplying that by the voltage used by the appliance. Most appliances in the United States use 120 volts. The amperes might be stamped on the appliance in place of the wattage. If not, find a clamp on ammeter an electrician's tool that clamps around one of the two wires on the appliance to measure the current flowing through it. You can obtain this type of ammeter in stores that sell electrical and electronic equipment. Take a reading while the device is running: this is the actual amount of current being used at that instant. If you cannot find or measure the current draw, the average wattages for typical pieces of classroom equipment are listed in Section 1: Electricity References.

**Transportation**

How carbonated is your commute? Different ways of getting to and from school affect our climate differently. Some options, such as driving alone in an inefficient, low mileage vehicle, generate more carbon dioxide emissions than others, such as riding a bike, taking the bus or walking. For simplicity, the Classroom Audit focuses just on how the teacher of your assigned classroom gets to and from school. (For the über dedicated climate crusaders, you can assess the transportation choices of the entire student body by conducting the Transportation Audit.) Find out how far and by what means each teacher travels to and from school each day. For teachers that drive, ask what kind of mileage their vehicle gets. If they aren't sure, ask for the make and model of their car and look it up at www.fueleconomy.gov

**Heating**

Keeping schools warm and cozy inside when it's cool outside uses a lot of energy, which in turn generates CO2 emissions. Measuring these emissions and finding ways to reduce them can be challenging and depend on many variables. For example, the type of fuel used to generate heat, the number of windows, the quality of insulation, and the age and location of the school building all figure into energy use and related CO2 emissions. Most of these are variables that individual students and teachers have no control over. One thing students and teachers can do, though, is adjust classroom temperature, if there is a controllable thermostat. For this category of the Classroom Audit, find out if the classroom has a controllable thermostat and, if so, to what temperature it is set.

**No control?** Classrooms without controllable thermostats cannot do much to influence how much energy they use for heat, but there are other ways to save CO2 through simple behavioral changes. For example, closing and opening windows or doors can affect the amount of energy that classrooms use. Include some of these tips in your Action Plan.
Solid Waste/Recycling  According to the EPA, about 4.4 pounds of waste is generated per person per day in the United States. Over the course of one school year (180 days), that adds up to 792 pounds of waste per person! Waste affects the environment in a number of ways, ranging from the greenhouse gases released after it’s dumped in a landfill and the emissions associated with transporting that waste to the landfill, to the emissions generated just to produce that item in the first place. According to the U.S. Environmental Protection Agency, each pound of waste produces roughly 1.75 pounds of greenhouse gas pollution as it journeys from your trash can to the landfill. Fortunately, there are many ways to shrink your waste and greenhouse gas emissions by reducing, reusing and recycling. In this section of the Classroom Audit you will look at how much trash each classroom generates in a week. Also examine whether wasteful habits are in practice such as using only one side of paper for printing/copying, or drinking bottled water or coffee from a paper cup, instead of using a reusable container. Just one grande size paper coffee cup is responsible for one quarter pound of greenhouse gas pollution. Does the classroom recycle? Americans use roughly 60 billion plastic bottles every year nearly 7 million an hour yet only one bottle out of every five is recycled. Filling a reusable water container or bringing your own mug helps reduce waste, save resources and cut down on emissions.

Accessed from:
2012© National Wildlife Federation. All Rights Reserved

I am reading this section:

The main ideas and things we should look for in this sections include:

- Number of computers
- Number of lights and light bulbs used
- Opportunities for recycling

6. In your cooperative learning groups, take a brief walk through the school and identify a classroom that you would like to audit with administration and grounds crew. You should record observations that you notice when you are looking at the classrooms. You may look for an record the following about the classrooms you visit:
- Access to running water
- Heating and cooling of the classroom

**My observations Include:**

---

**Day 3:**

1. Today you will complete an interview/audit with administration and the grounds crew. Make sure you take their **background information, audit sheets, clipboard** and visit the classroom they selected with administration and ground crew.
   
   Audit sheets can be found and printed from here: [http://www.nwf.org/pdf/Cool-School-Challenge/ES_CoolSchoolChallenge-AuditKit_Final.pdf](http://www.nwf.org/pdf/Cool-School-Challenge/ES_CoolSchoolChallenge-AuditKit_Final.pdf)
   
   Print pages 10-14 and bring them with your to your interview/ Audit. You will only need one copy per group. You will be recording your data using these audit forms.

2. Once your group has completed the audit forms, you will need to work as a group to calculate the carbon footprint of the classroom you audited using the calculator found here: [www.coolschoolchallenge.org](http://www.coolschoolchallenge.org) Ask your teacher to help you to print your results from the calculator.

3. Next, all groups will come back together and your teacher will facilitate a discussion based on what the different groups found during the audit. Be ready to share out your results.

4. Working in your cooperative learning groups, your group needs to draw conclusions about what you found and complete the following problem map:
Day 4:

1. Today is a research day! In your groups you should begin researching and coming up with solutions to help shrink their school’s carbon footprint.
2. Using websites, search engines and district data bases, research possible solutions to the problem and complete the following graphic organizer to help organize your ideas.

Accessed from:

http://greenappleproject.com/pbl/sample/high-school
Next you will need to complete a “Ticket out the Door” assessment. Your assessment will address the “big ideas” presented at the beginning of this handout. Review the big ideas and complete the following assessment.

**Decision-Making Matrix**

Complete the following table to analyze and evaluate the possible solutions to the problem. Then record any conclusions you can draw from your notes.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Pros</th>
<th>Cons</th>
<th>Consequences</th>
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</thead>
<tbody>
<tr>
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Accessed from:
http://greenappleproject.com/pbl/sample/high-school
Directions: Read and answer the following questions using complete sentences.

- What is meant by the term “Carbon Footprint”?

- What effect does your “Carbon Footprint” have on planet earth?

- What is carbon dioxide and what role does it play in our environment?

- Identify sources of carbon dioxide.

- What are some ways in which we can reduce our “Carbon Footprint”? 
Day 5:

1. Today is a presentation work day! All presentations should include the scope of the problem that your group found in auditing a classroom in their school. Furthermore, you will need to include possible solutions to this problem and analyze the pros and cons to their solutions. Your group may use any method to create your presentation. Review the presentation rubric before submitting your final presentation.

Day 6:

1. Today you will present your findings and action plan to the rest of the class, administration and grounds crew. Each group member needs to participate during the presentation. Your group members will be grading you on your participation throughout the case study.

Day 7:

1. Today we will finish viewing the rest of the presentations.
2. After the presentations are finished, you need to take a moment to rate your partners’ participation during the case study using the provided participation rubric.
3. While you are working your teacher will come by and provide you with feedback on your presentation.

How did your group do on the “Carbon Footprint” case study? Record your teacher’s feedback here:
4. Next in your groups, work together to complete the following Implementing the Solution handout based on what you saw during the presentations:

**Implementing the Solution**

1. Record the key points of the “master solution” compiled from all the presentations.

2. How will your group implement its part of the master solution? What do you need to apply the solution in real life?

3. What obstacles did you encounter while implementing the solution?

4. What adaptations were necessary?

5. How effective is the solution so far? How do you know?

6. What addition steps or new solutions will you use to reach the desired outcome?

Accessed from:
http://greenappleproject.com/pbl/sample/high-school
5. Your last and final task for this case study is to answer the follow self-reflection:

**Reflective Response**

1. Think back on the process of solving this problem. Describe how you responded to the problem and the problem-solving process.

2. What did you learn about course-related content?

3. What did you learn about learning and working in a group?

4. What questions or problems remain unanswered?

5. What actions do you plan to take based on what you learned?

Accessed from:
http://greenappleproject.com/pbl/sample/high-school
Case Study 4: Global Warming

Grade Level: 9th grade Living Environment/ Biology and/ or Environmental Science

Topic: Global Warming: Is it real? And if so what is causing it?

Time Period: 8, 55 minute class periods

Overview:

Global warming is a very controversial issue of our time. In fact it has led to a great debate over whether or not global warming is caused by human activities, or whether it is just part of the earth’s natural cycle. Furthermore, global warming is a hot topic among political parties and to further complicate things; it can be difficult to analyze climate change data which can be used to determine if global warming is contributed by human activities.

In this case students will build off of their previous case study on determining their school’s carbon footprint and determine if global warming is actually real, and if so, are human factors contributing the concept of global warming. Students will access a variety of resources including videos, radio clips, data, images websites, movies etc. to answer the following questions:

- Is climate change real or is it just a figment of the imagination?
- What is the evidence that our planet is warming?
- What are some examples of the consequences of a prolonged rising temperature of the earth?
- Why and how is this a problem?
- Do you think people's actions are causing global warming? What does the evidence show?
- What consequence does this process have for the common citizen or your community?

Once students have answered the above questions, they will need to complete one of the following in their groups: a presentation or a video on the truth about global warming, write a letter to congress addressing the issue and providing evidence and suggestions as to what should be done or be part of the change and looking around their community or school campus, identify an action that will contribute to mitigating the effects of global warming and develop an action plan. Student will then present their projects to their classmates.

Given that this will be case study number four that students will have worked on so far in this unit, the number of scaffolds will start to be reduced specifically during the research process. Students will continue to work in cooperative learning groups, and students with disabilities will receive a guided handout to help pace them through the case study. However, when it comes to the two days of group research students will be given websites and search terms but will be expected to locate and record relevant information on their own within their groups.
Standards:

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

Big Ideas:

- What is global warming? What is climate change? Is there a difference between the two?
- Is climate change real or is it just a figment of the imagination?
- What is the evidence that our planet is warming?
- What are some examples of the consequences of a prolonged rising temperature of the earth?
- Why and how is this a problem?
- Do you think people's actions are causing global warming? What does the evidence show?
- What consequence does this process have for the common citizen or your community?

Scaffolds used:

- Cooperative Learning groups
- Group roles
- Graphic organizers
- Guided handout
- Research “search” terms

Teacher notes for implementation:

Prior to starting this case study teachers may wish to assess student prior knowledge of the concepts of global warming and climate change. Once the pre-assessment is complete the
teacher may choose whether or not they give students the definition of global warming and climate change.

Prior to starting this case study, you will to create heterogeneous cooperative learning groups to be used throughout the case study. Furthermore, because this case study is rich in independent research, you may wish to have your librarian or technology member come in to complete a brief refresher on researching using the Internet and school databases.

Materials and resources needed:

- Assignment sheet for all students
- List of websites/ search terms
- Movie Cool It
- Guiding questions for analyzing sources
- Graphic organizer
- Guided students handout
- http://www.mrsoshouse.com/pbl/globwarm.html website in which the case study is based off of

Lesson Plans:

Day 1:

1. Assess students’ prior knowledge of global warming using a KWL graphic organizer. Students should complete the K- what I already know section and the W- what I want to know section. Students should aim to have at least 5 things in each of the two columns.
2. Next, conduct a brief class survey by posing the following questions: Is global warming real? Then ask students who responded “yes”, “how many of you thing global warming is caused by human activity?” The teacher should then record student results on chart paper and post them throughout the case study.
3. At this point, students should watch the video clip the “An Inconvenient Truth” accessed here: http://www.takepart.com/an-inconvenient-truth/film Students watch the video and should then add to their KWL chart. The teacher then leads a discussion on the video clip. Questions for discussion may include the following:
   - Is this video clip realistic? Do you think it paints an accurate picture? Why or why not?
   - What evidence is there that suggests that global warming is real and is caused by humans?
   - What are some the devastating effects that could result from global warming?
   - What evidence if any does this clip present that supports that global warming is occurring?
As students listen, have them draw a picture to represent what they are hearing. After the radio presentation, lead a brief discussion of the radio report and have students answer the following questions based on what they heard. Have students share their pictures. You may choose to stop the radio presentation after “A Story of Melting Ice” or continue on to listen to additional stories. Remind students that they might want to listen to more of these radio clips during their research process. Students will need access to Windows Media Player to play these radio clips. Questions for discussion include:

- Is this radio story realistic? Do you think it paints an accurate picture of global warming? Why or why not?
- What evidence is there that suggests that global warming is real and is caused by humans?
- What are some the devastating effects that could result from global warming?
- What evidence if any does this clip present that supports that global warming is occurring?

Day 2:

1. Introduce the case study assignment: Explain to students that they will work in groups to answer the following questions:
   - Is climate change real or is it just a figment of the imagination?
   - What is the evidence that our planet is warming?
   - What are some examples of the consequences of a prolonged rising temperature of the earth?
   - Why and how is this a problem?
   - Do you think people's actions are causing global warming? What does the evidence show?
   - What consequence does this process have for the common citizen or your community?

2. Further explain that this case study is primarily research based and at the end students will present the answers to the above questions by either creating a video or presentation that presents a true picture of global warming, writing a letter to congress explaining the extent of the problem and what action steps you would like to see them take to correct the problem, or be part of the change and looking around your school or community, identify an action that will contribute to mitigating the effects of global warming and develop an action plan.

3. Watch the movie Cool It either in its entirety – it will take a day and ½ watch or select a 30 min clip to watch. The movie can be accessed via Amazon Prime or can be found online for free here: https://archive.org/details/CoolIt

4. Hold a brief discussion about the movie and once again have the students analyze the film by answering the following questions:
   - Is this movie realistic? Do you think it paints an accurate picture of global warming? Why or why not?
• What evidence is there that suggests that global warming is real and is caused by humans?
• What are some the devastating effects that could result from global warming?
• What evidence if any does this clip present that supports that global warming is occurring?

5. Pose the following question as a “Ticket out the Door Assessment”: Which of the following paints an accurate picture of global warming: “An Inconvenient Truth trailer, the Radio clips on the “Dangers of a Warming Planet” or the movie clip form Cool It? Provide evidence to support your response

Day 3:

1. In their cooperative learning groups, students complete the routine, facts, questions and what to do next graphic organizer for global warming. Bring the class together and share out responses. Compile a class list of facts, questions and next steps.
2. Next students should work to define the problem statement using the following graphic organizer:

**Defining the Problem Statement**

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

110
6. Introduce students to the research process. Provide them with a list of websites and search terms to help them get started with their research. Some students may be provided with a generic graphic organizer to help them organize their information. You may recommend that students divide the work up by resources. For example each student may be responsible for reviewing and analyzing two sources.

7. Explain to students that they should consider the following questions when conducting their research:
   - Is climate change real or is it just a figment of the imagination?
   - What is the evidence that our planet is warming?
   - What are some examples of the consequences of a prolonged rising temperature of the earth?
   - Why and how is this a problem?
   - Do you think people's actions are causing global warming?
   - What consequence does this process have for the common citizen or your community?

Day 4 and 5:

1. Students continue their research and analysis of sources to answer questions presented on the assignment sheet. Teacher checks in with each group to monitor their progress toward research completion.
2. Assessment of big ideas. The teacher provides a “Ticket Out the Door” assessment to see if students understands the big ideas presented at the beginning of the case study.

Ticket Out the Door Assessment

Name: ____________________ Date: ____________________

Directions: Based on your research, answer the following questions in complete sentences.

- What is global warming? What is climate change? Is there a difference between the two?
- Is climate change real or is it just a figment of the imagination?
• What is the evidence that our planet is warming?

• What are some examples of the consequences of a prolonged rising temperature of the earth?

• Why and how is this a problem?

• Do you think people's actions are causing global warming? What does the evidence show?

• What consequence does this process have for the common citizen or your community

Day 6 and 7: Project work days

1. Review with students the assignment sheet. Answer any questions
2. Students take two class days to create a video addressing the truth of global warming, write a letter to congress providing their opinion on the matter and actions they would like to see take place or develop a local action plan to combat global warming.
Day 8: Presentation Day

1. Share their presentations with classmates and teachers. Students complete self and partner evaluations forms.
Global Warming Assignment Sheet

Name: ___________________ Date: ______________

Group members: __________________________________________________

Case Study:

Global warming is a very controversial issue of our time. In fact it has led to a great debate over whether or not global warming is caused by human activities, or whether it is just part of the earth’s natural cycle. Furthermore, global warming is a hot topic among political parties and to further complicate things; it can be difficult to analyze climate change data which can be used to determine if global warming is contributed by human activities. Even still some people might believe that consequences of global warming are over dramatized and extreme.

Your Task: Complete research to answer the following questions:

- Is climate change real or is it just a figment of the imagination?
- What is the evidence that our planet is warming?
- What are some examples of the consequences of a prolonged rising temperature of the earth?
- Why and how is this a problem?
- Do you think people's actions are causing global warming? What does the evidence show?
- What consequence does this process have for the common citizen or your community?

Your final project: Select one of the three options to complete and present to your class:

1. Write a letter regarding this issue to one of the individuals that represent you in the U.S. Congress. Tell them how you feel about this issue and what you believe should be done about it. Endeavor to cite specific examples that relate to your community. Point to their previous voting record on relevant issues

2. Look around your community or school campus. Identify an action that will contribute to mitigating the effects of global warming. It does not need to be a big action. Craft a plan regarding the action. Appeal to your community leaders, the members of your family, the members of a club you belong to, your student council, your school's administration and/or your school board to make the change.

3. Or make a very education video about the global warming issue
Research Links and Search Terms

Reports from a Warming Planet

C-Span – Search “Global Warming” or “Climate Change”

Cool It

Climate Change Debate

Warmest Year on Record

Climate Change

Hear From Steven Chu

Union of Concerned Scientists

Intergovernmental Panel on Climate Change ***

Office of Science and Technology Policy – Search “Global Warming” or “Climate Change”

Who killed the electric car?

Energy Security

The Encyclopedia of Earth

Capturing Carbon

Search Terms:

“Climate Change”

“Global Warming”

“Warming Planet”

“Climate cycles of earth”
Directions: Based on your research, answer the following questions in complete sentences.

- What is global warming? What is climate change? Is there a difference between the two?

- Is climate change real or is it just a figment of the imagination?

- What is the evidence that our planet is warming?

- What are some examples of the consequences of a prolonged rising temperature of the earth?

- Why and how is this a problem?

- Do you think people's actions are causing global warming? What does the evidence show?

- What consequence does this process have for the common citizen or your community?
# Note Catcher tool for research

**Directions:** Use this tool to record notes on the resources you view and analyze.

**Source:** ________________________________________________

<table>
<thead>
<tr>
<th>Questions to keep in mind</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is climate change real or is it just a figment of the imagination?</td>
<td></td>
</tr>
<tr>
<td>What is the evidence that our planet is warming?</td>
<td></td>
</tr>
<tr>
<td>What are some examples of the consequences of a prolonged rising temperature of the earth?</td>
<td></td>
</tr>
<tr>
<td>Why and how is this a problem?</td>
<td></td>
</tr>
<tr>
<td>Do you think people's actions are causing global warming? What does the evidence show?</td>
<td></td>
</tr>
<tr>
<td>What consequence does this process have for the common citizen or your community?</td>
<td></td>
</tr>
</tbody>
</table>
Big Ideas To Focus On:
- What is global warming? What is climate change? Is there a difference between the two?
- Is climate change real or is it just a figment of the imagination?
- What is the evidence that our planet is warming?
- What are some examples of the consequences of a prolonged rising temperature of the earth?
- Why and how is this a problem?
- Do you think people's actions are causing global warming? What does the evidence show?
- What consequence does this process have for the common citizen or your community?

Day 1:

1. What do you already know about Global warming?

**Directions:** Complete the following KWL graphic organizer for global warming.

### What is Global Warming?

**Directions:** Complete the following KWL graphic organizer for global warming.

<table>
<thead>
<tr>
<th>What I already know about the Global Warming</th>
<th>What I would like to know about Global Warming</th>
<th>What I have learned about Global Warming</th>
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</tbody>
</table>
2. Answer the following questions in preparation for the quick survey.
   - Is global warming real?

   **Answer:**

   - Do you think global warming is caused by human activity?

   **Answer:**

3. Watch the following video clip “An Inconvenient Truth” found here: 
   Once you have watched the video, go back and add to your KWL chart. Be ready to share your responses with the class.

4. Based on the video clip, consider the following questions (take a brief note on each):
   - Is this video clip realistic? Do you think it paints an accurate picture? Why or why not?

   - What evidence is there that suggests that global warming is real and is caused by humans?

   - What are some the devastating effects that could result from global warming?

   - What evidence if any does this clip present that supports that global warming is occurring?
8. Next Listen to: Reports from a Warming Planet found here:
   http://americanradioworks.publicradio.org/features/earlysigns/index.html

   While listening to the clip your teacher selected, draw or sketch a picture to represent what you are hearing.

   **Draw your picture here:**

   During the class discussion on the radio clip take a brief note on the following questions:
• Is this radio story realistic? Do you think it paints an accurate picture of global warming? Why or why not?

• What evidence is there that suggests that global warming is real and is caused by humans?

• What are some the devastating effects that could result from global warming?

• What evidence if any does this clip present that supports that global warming is occurring?

Day 2:

1. Look and follow along as your teacher goes over the assignment sheet. If you have any questions write them down here:

   My Questions:

2. Review the presentation options and discuss them with your group members. Record the presentation format that your group chose here:

   Our presentation format is: ________________________________

3. Watch the movie Cool It found online for free here: https://archive.org/details/CoolIt

   While you watch consider the following questions. Take a brief note below:
   • Is this movie realistic? Do you think it paints an accurate picture of global warming? Why or why not?
• What evidence is there that suggests that global warming is real and is caused by humans?

• What are some the devastating effects that could result from global warming?

• What evidence if any does this clip present that supports that global warming is occurring?

Be prepared to share responses with the whole class during a movie discussion.

Ticket out the Door Assessment:

Directions: Answer the following question. Then tear off your response and hand it to your teacher as you leave class.

1. Which of the following paints an accurate picture of global warming: “An Inconvenient Truth trailer, the Radio clips on the “Dangers of a Warming Planet” or the movie clip form Cool It? Provide evidence to support your response
Day 3:

1. Meet in your cooperative learning groups and review and assign group roles.  
   My assigned role is: ________________________________________

2. In your learning group complete the facts, questions and what to do next graphic organizer for global warming.
   
   **Facts and Questions**

<table>
<thead>
<tr>
<th>Facts</th>
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<th>What we should do</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

   Be ready to share out your responses with the rest of the class.
3. Next with your group members, work together to define the problem statement using the following graphic organizer:

**Defining the Problem Statement**

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

   How can we (see A above)...

   in such a way that (see B above)...

Accessed from:
http://greenappleproject.com/pbl/sample/high-school
4. Your teacher will now introduce the research process to you and model searching for information on the Internet. Review the provided resources handout and record any questions you have for your teacher below:

   **My Questions:**

   

5. **Remember: To consider the following questions while researching:**
   - Is climate change real or is it just a figment of the imagination?
   - What is the evidence that our planet is warming?
   - What are some examples of the consequences of a prolonged rising temperature of the earth?
   - Why and how is this a problem?
   - Do you think people's actions are causing global warming?
   - What consequence does this process have for the common citizen or your community

6. Look at the following resources on your handout. Select three that you would like to view and analyze. Record your selections below:

   **My resources to research are:**

   

7. Next use your note catcher tool to collect information on global warming you’re your selected resources.

**Day 4 and 5: Research days**

1. Today you will continue researching the topic of global warming while answering the key questions found on your note catcher tool for your selected resources. Your teacher will check in with your group to see how your research is progressing.
2. At the end of Day 5 you will complete the Assessment of Big Ideas for the global warming unit. Complete the assessment and submit it to your teacher prior to leaving class.

Day 6 and 7: Project work days

1. Today your teacher will review the assignment sheet and answer any questions you may have. Record any questions you have below:
   
   My Questions:

3. You will now select one of the following based on the assignment sheet:

   **Your final project:** Select one of the three options to complete and present to your class

   1. Write a letter regarding this issue to one of the individuals that represent you in the U.S. Congress. Tell them how you feel about this issue and what you believe should be done about it. Endeavor to cite specific examples that relate to your community. Point to their previous voting record on relevant issues.

   2. Look around your community or school campus. Identify an action that will contribute to mitigating the effects of global warming. It does not need to be a big action. Craft a plan regarding the action. Appeal to your community leaders, the members of your family, the members of a club you belong to, your student council, your school’s administration and/or your school board to make the change.

   3. Or make a very education video about the global warming issue

   **As a group select one of the above choices and record your group’s choice below:**

   Our group decided on:

4. You have two days to complete the project work. Good Luck!
Day 8: Presentation Day

1. Today you will present your projects to your classmates. All group members must participate in the presentation. Upon completion of the presentations you will complete a self-reflection rubric, a partner participation rubric and evaluations for other groups.
Case Study 5: Alternative Energy Sources

Grade Level: 9th grade Living Environment/ Biology and/ or Environmental Science

Topic: Alternative Energy Sources: Making a positive impact on our environment

Time Period: 6, 55 minute class periods

Overview:

At this point in the unit students have mostly experienced the negative impact humans can have on the environment. Students were introduced to issues related to water and air pollution, and invasive species; all instances where humans have contributed to these environmental issues. Furthermore, students have looked at their lifestyle habits and how their habits can generate a large carbon footprint. Finally students go on to determine the truth behind global warming; a controversial issue that humans are being blamed for. At this point in time it is necessary for students to identify positive changes that humans can take to protect our environment. This leads us to a case study on alternative energy sources. In this case study students will be presented with a problem in which the town council is looking for information on alternative energy sources and ways to reduce out use of oil and coal, two energy sources that are becoming scarce and are the leading cause of pollution communities.

In this case study students will research various alternative energy sources and consider the following questions during the research process:

- **How can the actions/choices of people in your community be contributing to the problem?**
- **Which would be the best alternative source(s) of energy for your community?**
- **How can your school conserve energy? How can you conserve energy?**

After conducting their research on various alternative energy sources, students will need to compare and contrast two sources and decide which would be best for their community and why. Students will select the best alternative energy for their community and complete a print or digital project to explain their choices and support for their selection as it relates to their community.

Given that this will be the last case study in this unit, the number of scaffolds will be reduced specifically during the research process. Students will continue to work in cooperative learning groups, and students with disabilities will receive a guided handout to help pace them through the case study. However, when it comes to group research days students will be given websites and search terms but will be expected to locate and record relevant information on their own within their groups.
Standards:

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

Big Ideas:

- What is renewable energy? What is non-renewable energy?
- Identify several alternative energy sources.
- What are the advantages and disadvantages to various alternative energy sources?
- What alternative energy sources would be best for your community?
- Which sources are constant and reliable?
- Are the alternative energy sources affordable?
- How does alternative energy affect the environment?

Scaffolds used:

- Cooperative Learning groups
- Group roles
- Graphic organizers
- Guided handout
- Research “search” terms and websites

Teacher notes for implementation:

Prior to starting this case study teachers may wish to assess student prior knowledge of the concepts of alternative energy to see what students already know about energy resources. This may also be helpful in grouping students based on their current level of knowledge. Once the pre-assessment is complete the teacher may choose whether or not they give students the
definition alternative energy sources, renewable energy sources and non-renewable energy sources.

Prior to starting this case study, you will to create heterogeneous cooperative learning groups to be used throughout the case study. Furthermore, because this case study is rich in independent research, you may wish to have your librarian or technology member come in to complete a brief refresher on researching using the Internet and school databases.

Materials and resources needed:

- Assignment sheet for all students
- List of websites and search terms for students
- Graphic organizer
- Guided students handout
- Alternative Energy PBL- website from which this case study came from

Lesson Plans:

Day 1:

1. Start today by assessing students prior knowledge about alternative energy sources. Students should complete the following handout:

   Energy Alternatives and Conservation
   A Problem-Based Learning Project about Energy and its conservation
   - What do you know about alternative energy sources, renewable energy and conserving energy?
   - Name some alternative energy sources.
   - Identify some renewable energy sources
   - List some problems/difficulties that people suggest regarding the use of non-fossil fuel sources of energy.
   - What are some positives about using renewable energy sources?
   - The National Renewable Energy Laboratory says the critical step is to conserve energy and to stop wasting it. How can people conserve energy in your home, school and community?

2. Once students have completed the pre-assessment discuss students’ answers and compile a list of responses on chart paper to post throughout the case study.

3. Next have students watch a brief video on alternative energy found here: Alternative Energy After the video, briefly discuss what the students saw and record any newly learned information about alternative energy on chart paper
4. Next Introduce the following case study:
http://mrsoshouse.com/pbl/energy/index.htm

Your class is attending a town council meeting.


Councilwoman Turbine reads from a *Time* magazine article.

"Although many economists argue that it will be difficult and expensive to find an alternative to oil and coal--and that we should delay the transition for as long as possible--their position is based on a technological pessimism that seems out of place today. The first automobiles and computers were difficult to use and expensive, but the pioneers persevered and made improvements, and ultimately triumphed in the marketplace.

Just as automobiles followed horses and computers displaced typewriters, so can the advance of technology make today's smokestacks and gas-powered cars look primitive, inefficient and uneconomical. Unlike fossil fuels, renewable energy never runs out, and geologists will not have to travel to the Alaskan North Slope or the shores of the Caspian Sea to find new sources. The sunlight falling on the surface of the earth each day contains 6,000 times as much energy as is used by all countries combined. Studies show that covering the existing flat-roof space of many cities with solar cells could meet half to three-quarters of their electricity needs. In the U.S., North Dakota, South Dakota and Texas together are swept by sufficient wind to meet the electricity needs of the entire country." Flavin, Christopher., *Clean as a Breeze*, *Time*, Dec. 15, 1997.

Mayor Solare urges that the council look at alternatives. She wants your community to thrive, even as oil becomes increasingly expensive and scare. She says the effort begins with changing the energy strategy to alternative sources and to changing how we use the energy we have. Mayor Solare turns to your class in the audience.

"Our young people will be the ones to live their lives with this new world of energy. They are open to new ways of thinking. What do they suggest?"

Your teacher says your class will look into alternative energies and get back to the Council.

**How can the actions/choices of people in your community be contributing to the problem?**

**Which would be the best alternative source(s) of energy for your community?**

**How can your school conserve energy? How can you conserve energy?**
5. At this point students should break into their cooperative learning groups and review their assigned roles.
6. Next students should complete the routine Facts, Questions and What to do next? Graphic organizer.

   **Facts and Questions**

<table>
<thead>
<tr>
<th>Facts</th>
<th>Questions</th>
<th>What we should do next?</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
7. Next students should work together to develop a problem statement using the following graphic organizer:

**Defining the Problem Statement**

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

Accessed from:
http://greenappleproject.com/pbl/sample/high-school

**Day 2:**

1. Start by gathering as a whole group, share and compile a group list of facts and questions and what to do next.
2. Administer the following planning sheet, and students should reconvene into their cooperative learning groups. Students work as a group to complete the following handout.
3. Next students are ready to begin the research process. Students should use the following graphic organizer as a tool to help them in the research process.

<table>
<thead>
<tr>
<th>List the alternative energy sources you may have missed in the pre-assessment</th>
</tr>
</thead>
</table>

4. At this point students should begin general research on the various types of alternative energy. Of the ones that find, students answer the following question:

<table>
<thead>
<tr>
<th>Identify the alternative energy sources that are especially well suited to your community</th>
</tr>
</thead>
</table>

5. Students identify two viable alternative energy resources for their community and compare and contrast the two using the following diagram:
Compare and Contrast Chart Graphic Organizer

Item #1 ___________________________  Item #2 ___________________________

How are they alike?

________________________________________________________

________________________________________________________

________________________________________________________

How are they different?

________________________________________________________

________________________________________________________

________________________________________________________

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________________________________________________________

________________________________________________________

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6. Students select the one alternative energy sources that would be best for their community to further research and consider the following questions during the research process.

**Research Questions to Consider**

**Selected Energy Source:** __________________________________________________________

<table>
<thead>
<tr>
<th>Guiding Questions</th>
<th>Research Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify the advantages of the energy source for your community.</td>
<td></td>
</tr>
<tr>
<td>2. Make special notes on how your community might be able to use that form of energy</td>
<td></td>
</tr>
<tr>
<td>3. What are the challenges for this form of alternative energy?</td>
<td></td>
</tr>
<tr>
<td>4. Have any solutions been offered?</td>
<td></td>
</tr>
<tr>
<td>5. Continue additional research.</td>
<td></td>
</tr>
</tbody>
</table>
Day 3: Research Day 2

1. Today students will continue to research their selected alternative energy source. Students need to make sure that they are addressing the following questions:
   - How can the actions/choices of people in your community be contributing to the problem?
   - Which would be the best alternative source(s) of energy for your community?
   - How can your school conserve energy? How can you conserve energy?
   - Identify the advantages of the energy source for your community.
   - Make special notes on how your community might be able to use that form of energy
   - What are the challenges for this form of alternative energy?
   - Have any solutions been offered?

2. Students complete the “Big Ideas Assessment”

   **Alternative Energy “Big Ideas Assessment”**

   **Name:** ___________________  **Date:** _____________________

   **Directions:** Answer the following questions using complete sentences

   - What is renewable energy? What is non-renewable energy?

   - Identify several alternative energy sources.

   - What are the advantages and disadvantages to various alternative energy sources?

   - What alternative energy sources would be best for your community and why?
• Which sources are constant and reliable?

• Are the alternative energy sources affordable?

• How does alternative energy affect the environment?

**Day 4: Project Work**

1. Remind students of the assignment that they will need to complete once they have completed their research.

Assignment:

Based on your selected alternative energy source, create a poster or digital presentation/video explaining why you chose the source you did for your community. How will this energy source help to solve the current problem? Be sure to include the Pros and Cons of your selected source.

Also, be sure to address the following questions in your presentation:

• How can the actions/choices of people in your community be contributing to the problem?
• Which would be the best alternative source(s) of energy for your community?
• How can your school conserve energy? How can you conserve energy?
• Identify the advantages of the energy source for your community.
• Make special notes on how your community might be able to use that form of energy
• What are the challenges for this form of alternative energy?
• Have any solutions been offered?
Day 5: Presentations/ Evaluations

1. Students present their presentations. Students evaluate each other’s presentations providing feedback.
2. Students complete a self-evaluation and group member evaluations.

Day 6: Discussions and wrap up

1. Finish presentations if necessary.
2. Next as a class, students will discuss their findings from the presentations. The teacher will record their finding for the following questions on chart paper
   • How many people support each alternative energy source?
   • Which alternative energy source would be the best for the community?
   • What are the reasons for this selection?
   • Develop a plan to conserve energy in your school and community.
   • Create an action plan for your community and list the steps involved in implementing the plan
   • How could you motivate people to cooperate?
   • What are some challenges you might face?
Case Study 5: Student Worksheet

Alternative Energy Sources

Name: ______________________                     Date: ____________________

Big Ideas to Focus On:

- What is renewable energy? What is non-renewable energy?
- Identify several alternative energy sources.
- What are the advantages and disadvantages to various alternative energy sources?
- What alternative energy sources would be best for your community?
- Which sources are constant and reliable?
- Are the alternative energy sources affordable?
- How does alternative energy affect the environment?

Day 1:

1. First complete the Alternative Energy Assessment. This is to see what you already know about alternative energy.
Energy Alternatives and Conservation
A Problem-Based Learning Project about Energy and its conservation
Directions: Answer the following questions honestly using complete sentences.

1. What do you already know about alternative energy sources, renewable energy and conserving energy?

2. Name some alternative energy sources.

3. Identify some renewable energy sources

4. List some problems/difficulties that people suggest regarding the use of non-fossil fuel sources of energy.

5. What are some positives about using renewable energy sources
6. The National Renewable Energy Laboratory says the critical step is to conserve energy and to stop wasting it. How can people conserve energy in your home, school and community?

Be ready to share your responses with the rest of the class.

2. Next, watch a brief video on alternative energy found here: Alternative Energy

Record your observations and newly learned information from the video here:

Be ready to discuss your observations with the rest of the class.
Your class is attending a town council meeting.


Councilwoman Turbine reads from a *Time* magazine article.

"Although many economists argue that it will be difficult and expensive to find an alternative to oil and coal--and that we should delay the transition for as long as possible--their position is based on a technological pessimism that seems out of place today. The first automobiles and computers were difficult to use and expensive, but the pioneers persevered and made improvements, and ultimately triumphed in the marketplace. Just as automobiles followed horses and computers displaced typewriters, so can the advance of technology make today's smokestacks and gas-powered cars look primitive, inefficient and uneconomical. Unlike fossil fuels, renewable energy never runs out, and geologists will not have to travel to the Alaskan North Slope or the shores of the Caspian Sea to find new sources. The sunlight falling on the surface of the earth each day contains 6,000 times as much energy as is used by all countries combined. Studies show that covering the existing flat-roof space of many cities with solar cells could meet half to three-quarters of their electricity needs. In the U.S., North Dakota, South Dakota and Texas together are swept by sufficient wind to meet the electricity needs of the entire country." Flavin, Christopher., *Clean as a Breeze, Time*, Dec. 15, 1997.

Mayor Solare urges that the council look at alternatives. She wants your community to thrive, even as oil becomes increasingly expensive and scare. She says the effort begins with changing the energy strategy to alternative sources and to changing how we use the energy we have. Mayor Solare turns to your class in the audience.

"Our young people will be the ones to live their lives with this new world of energy. They are open to new ways of thinking. What do they suggest?"

Your teacher says your class will look into alternative energies and get back to the Council.

**How can the actions/choices of people in your community be contributing to the problem?**

**Which would be the best alternative source(s) of energy for your community?**

**How can your school conserve energy? How can you conserve energy?**
4. At this point you will need to break into your assigned cooperative learning groups. Review your assigned role and description of your responsibilities.

My role is: ____________________________________________________________

5. Next in your group, complete the following Facts, Questions and What to do next? Graphic organizer.

**Facts and Questions**

<table>
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6. Next, work together to develop a problem statement using the following graphic organizer:

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**Defining the Problem Statement**

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

---

Accessed from:  
http://greenappleproject.com/pbl/sample/high-school
Day 2:

1. Today you will start by gathering as a whole group. You will share and compile a group list of facts and questions and what to do next.
2. Next, complete the following planning sheet and begin to start your research.
3. Use the following prompts and graphic organizers to help you through the research process.
4. Use the provided “Students Resources and Search Terms” handout to help you

| List the alternative energy sources you may have missed in the pre-assessment |

5. Begin general research on the various types of alternative energy. Of the ones that find, students answer the following question:

| Identify the alternative energy sources that are especially well suited to your community |
6. Identify two viable alternative energy resources for your community and compare and contrast the two, using the following diagram:

**Compare and Contrast Chart Graphic Organizer**

![Diagram of a compare and contrast chart]

- **Item #1**
- **Item #2**

**How are they alike?**

- 
- 
- 
- 
- 

**How are they different?**

- 
- 
- 
- 
- 

- 
- 
- 
- 

7. Next, select the one alternative energy source that would be best for your community to further research and consider the following questions during the research process.

**Research Questions to Consider**

**Selected Energy Source:**

<table>
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<tr>
<th>Guiding Questions</th>
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</tr>
<tr>
<td>10. Continue additional research.</td>
<td></td>
</tr>
</tbody>
</table>
Day 3: Research Day 2

1. Today you will continue to research their selected alternative energy source. You need to make sure that your group is addressing the following questions:
   - How can the actions/choices of people in your community be contributing to the problem?
   - Which would be the best alternative source(s) of energy for your community?
   - How can your school conserve energy? How can you conserve energy?
   - Identify the advantages of the energy source for your community.
   - Make special notes on how your community might be able to use that form of energy
   - What are the challenges for this form of alternative energy?
   - Have any solutions been offered?

2. Review the “Big Ideas” presented at the beginning of the case study. Then complete the following “Big Ideas Assessment” for alternative energy sources.
Alternative Energy “Big Ideas Assessment”

Name: ___________________                          Date: ___________________

Directions: Answer the following questions using complete sentences

- What is renewable energy? What is non-renewable energy?

- Identify several alternative energy sources.

- What are the advantages and disadvantages to various alternative energy sources?

- What alternative energy sources would be best for your community and why?

- Which sources are constant and reliable?

- Are the alternative energy sources affordable?

- How does alternative energy affect the environment?
Day 4: Project Work Day

1. Your teacher will remind you of the assignment that you will need to complete once your group has completed their research.
2. Please see the attached assignment sheet. If you have any questions about the assignment, please record them below:

<table>
<thead>
<tr>
<th>Questions that I have:</th>
</tr>
</thead>
</table>

Day 5: Presentations/ Evaluations

1. Today you will present your project. All students must participate when it is time for their group to present. You will have the opportunity to evaluate each presentation when they are finished
2. Next you will need to complete a self-evaluation and group member evaluations.

Day 6: Discussions and wrap up

1. Today we will finish presentations if necessary.
2. Next as a class, we will discuss the findings from the presentations. Your teacher will record your findings for the following questions on chart paper:
**Take notes on the questions below as your teacher reports the class findings**

- How many people support each alternative energy source?
- Which alternative energy source would be the best for the community?
- What are the reasons for this selection?
- Develop a plan to conserve energy in your school community.
- Create an action plan for your community and list the steps involved in implementing the plan.
- How could you motivate people to cooperate?
- What are some challenges you might face?
Student Resource and Search Terms Sheet

Renewable Energy Sources

http://energy.gov/eere/education/education-homepage

Wind Power

Solar Power

Manure

Solar Power

Gassing up with garbage

Hydroelectric Power

Fossil Fuels

Additional Resources can be found here

“Search Terms”

“Alternative Energy”

“Renewable Energy”

“Solar Power”, “Wind Power”, “Hydro Power”

“Fossil Fuels”
Case Study:

Town council members need your help. They understand the scarcity of fossil fuels and are looking for alternatives that would work in your community. They have called on your Living Environment class to help jump start the research process. Your teacher says your class will look into alternative energies and get back to the Council.

The council would like you to consider the following questions:

- **How can the actions/choices of people in your community be contributing to the problem?**
- **Which would be the best alternative source(s) of energy for your community?**
- **How can your school conserve energy? How can you conserve energy?**

**Your Task:** Complete research on alternative energy sources that would be of use to your local community. Be sure to answer the following questions:

- Identify the advantages of the energy source for your community.
- Make special notes on how your community might be able to use that form of energy.
- What are the challenges for this form of alternative energy?
- Have any solutions been offered?

**Your final project:** You will need to create a poster or a digital presentation/video based on your selected alternative energy source. Create a poster or digital presentation/video explaining why you chose the source you did for your community. How will this energy source help to solve the current problem? Be sure to include the Pros and Cons of your selected source. In addition, make sure you address the research questions presented in the “**Your Task**” section.

**Do you have any questions? Record them here:**
Case Study 6: Invasive Species 1

Grade Level: 9th grade Living Environment/ Biology and/ or Environmental Science

Topic: Invasive Species: “Can Suminoe Oysters Save Chesapeake Bay?” by Nieman & Liu
Copyright © 2006 by the National Center for Case Study Teaching in Science.
Originally published 02/22/06 at
http://www.sciencecases.org/chesapeake_bay/chesapeake_bay.asp

Time Period: 5, 55 minute class periods

Overview:

This case study will introduce students to the concept of invasive species. The term invasive species often has negative connotations and a majority of the time students are taught that introducing a non-native species will have negative consequences on the environment and surrounding ecosystems. Students will work through the case study “Can Suminoe Oysters Save Chesapeake Bay?” by Nieman & Liu. Additional supports will be added in order to help students with disabilities to progress through the case study with a relatively high level of independence.

This case study may be accessed from the National Center for Case Study Teaching in Science found here: http://sciencecases.lib.buffalo.edu/cs/. For this case study students will need to read closely the two page case and will then have to answer a series of provided questions. Additionally, students will have to conduct research in order to answer the questions completely. Students will present their answers to the class in the form of a presentation (PowerPoint, Prezi. etc.)

Given that this case study is lengthier in its reading content, the teacher may wish to complete a prior lesson on reading closely for details and coding the text. Student will then complete the close reading within their cooperative learning groups. To help make this case study accessible to all students, additional graphic organizers and resources will be added to facilitate the problem solving process.

Furthermore, since this is the second to last case study presented in this unit, the number of scaffolds will be reduced. For this particular case study, students with disabilities will not be provided with a step-by-step guided handout. Students will continue to work in cooperative learning groups and will be provided with graphic organizers.

Standards:

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.
7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of
population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

**Big Ideas:**

- What is an invasive species?
- Identify several known invasive species found within the United States.
- What impact do invasive species have on native ecosystems?
- How do invasive species make their way into native areas?
- Identify both the pros and cons to invasive species

**Scaffolds used:**

- Cooperative Learning groups
- Group roles
- Graphic organizers
- Research “search” terms and websites

**Teacher notes for implementation:**

Prior to starting this case study teachers may wish to include an explicit teaching lesson on close reading. In this case study students will be required to read an information rich case study which will serve as the foundation of their research process. Students will use the case study to help direct them in the research necessary for answering the provided questions. Therefore the students will need to read the case closely to identify the facts, develop questions and formulate the problem statement.

At teacher discretion, students may closely read the case study as a whole group facilitated by the teacher or they may read it in pairs within their cooperative learning groups with a final whole group discussion once the case has been closely read. After considering a specific population of students for whom this project was intended for, this specific project will include a whole class close reading and discussion of the case study. Students will then utilize the large group discussion to brainstorm their facts, questions, next steps and problem statement.

Prior to initiating the case study the teacher should carefully determine heterogeneous groups for the study.

**Materials and resources needed:**

- Printed case study and questions: Can Suminoe Oysters Save Chesapeake Bay?
- List of search terms for students
Lesson Plans:

**Day 1:**

1. The teacher should first start the class by asking students to complete a “Ticket in the Door”: What do you believe is meant by the term **invasive species**? The teacher quickly collects and shares responses with the class. The teacher will lead a brief discussion and as a class the students will develop a working definition of invasive species means. The teacher should post this definition on the board for students to reference during the case study.

2. Next, the teacher should introduce the case study and assignment sheet which will include the final presentation guidelines.

3. The teacher briefly reminds the students of the close reading procedure and the codes that they will use in order to annotate the text. The teacher reminds students that annotate means to code and to take notes on the text itself.

4. Students start by silently reading through the case study. Students should just read at this point.

5. The teacher then reads the case study in its entirety to the class. Then the teacher will re-read the case asking students to annotate the text as they follow along. Students should use the following codes: $F=$ facts presented, $Q=$ questions I have/ I need more information (Students should write questions they have in the margins) $P=$ the problem $*= $ any information that might be critical or should be considered when solving the case. For students with disabilities, it may be helpful to have a book mark with these annotation codes, to use while reading. Furthermore, the teacher should remind students to box unfamiliar words. Some words students may have difficulty with include: **constituents, swing vote, sterile, native, habitat degradation, over-harvesting, pristine, kudzu, fertile, proliferate** Depending on your population of students, you may decide to give the definitions to these words up-front or you may have students take time to look up the meaning of these words.

6. Teacher leads a large group discussion on what students annotated any why.

**Day 2:**

1. Today students will divide into their pre-determined cooperative learning groups. Students will select their role and review their responsibilities.

2. Students will start by re-reading the case study and making an additional annotations.

3. Students share out additional annotations.

4. Students complete the following facts, questions, and next steps graphic organizer. The recorder will record responses on chart paper.
### Facts and Questions

<table>
<thead>
<tr>
<th>Facts</th>
<th>Questions</th>
<th>What we should do next</th>
</tr>
</thead>
</table>

5. Depending how the groups are working, the teacher may decide to pull the group back for a final discussion of their facts questions and next steps or the students may move forward with defining the problem statement.

6. Students use the following graphic organizer to help them arrive at their problem statement. Some students may not need this graphic organizer at this point.
Defining the Problem Statement

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

   How can we (see A above)...

   in such a way that (see B above)...

Accessed from:

http://greenappleproject.com/pbl/sample/high-school

Day 3: Research Day

1. Based on the column titled What we should do next? Students work in their groups to research information necessary for helping them to formulate complete well-reasoned responses to the provided questions. Students may divide up the work by having each student work on researching one question.
**Day 4: Presentation work day**

1. The teacher reviews the task assignment sheet with students.
2. Students use this period to finish answering their questions and organizing their responses into a PowerPoint presentations or other approved format.

**Day 5: Presentation Day**

1. Today each group will present their findings by giving a 10-15 minute presentation.

**Day 6: Debriefing**

1. Students meet in their cooperative learning groups and complete presentation rubrics for each group and then complete participation rubrics for themselves and their groups’ members.
2. Students then begin debriefing on the presentations that they saw. This should be a discussion within their cooperative learning groups. Some students may need to use the following graphic organizer to record their thoughts and ideas.
Implementing the Solution

1. Record the key points of the “master solution” compiled from all the presentations.

2. How will your group implement its part of the master solution? What do you need to apply the solution in real life?

3. What obstacles did you encounter while implementing the solution?

4. What adaptions were necessary?

5. How effective is the solution so far? How do you know?

6. What addition steps or new solutions will you use to reach the desired outcome?


3. The teacher then wraps up the case study by facilitating a discussion based on the above handout “Implementing the Solution”

Student handouts necessary for this case study will be found on the following pages.
List of search terms for students:

“Chesapeake Bay”
“Save the oysters Chesapeake bay”
“Suminoe oysters”
“Save the Chesapeake bay”

Websites:
http://www.cbf.org/


http://www.chesapeakebay.net/blog/post/eight_ways_to_save_the_chesapeake_bay_in_2012

http://environment.nationalgeographic.com/environment/habitats/chesapeake-save-bay/
### Facts and Questions

<table>
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<tr>
<th>Facts</th>
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</thead>
<tbody>
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<td></td>
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Defining the Problem Statement

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

Accessed from:
http://greenappleproject.com/pbl/sample/high-school
Presentation Guidelines

Invasive Species- Chesapeake Bay- Assignment Sheet

Name: ___________________                                        Date: ______________

Group members: ______________________________________________________

Case Study Directions:

Closely read the provided case study. You will then need to work in your groups to answer the provided case study questions. Your group will need to work together to complete research in order to answer the questions completely.

Questions:

Questions
1. Who is being affected by this decision and how?
2. If the decision is made to introduce the Suminoc oysters, what might be the long-term effects on the environment, the communities, the people?
3. Any choice implies other lost opportunities. In what alternative ways might this money be spent to deal with the Chesapeake Bay’s problems and serve constituents?
4. What might this region look like in 20 years if nothing is done?
5. What should Senator Ben Fisher do?

Your Task: Complete research related to the case study and answer the above questions. Once you have complete answers, organize your response into a PowerPoint presentation or another approved form. Organize your presentation so that there is one slide per question.

Your final product: You should submit all of your individual completed worksheets and graphic organizers. Your final product will be a computer based presentation (PowerPoint etc.) Each question will need to be addressed in your presentation. Remember to make your presentation visually appealing to your audience.

Do you have any questions? Record them here:
Annotation bookmarks
(Photo copy and cut one for each student)

<table>
<thead>
<tr>
<th>Annotation Codes for Reading Closely</th>
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Case Study 7: Invasive Species 2

**Grade Level:** 9th grade Living Environment/ Biology and/ or Environmental Science

**Topic:** Invasive Species: “Response to Invasion” by Anastasia P. Maines

Case copyright held by the National Center for Case Study Teaching in Science, University at Buffalo, State University of New York. Originally published April 9, 2013.

**Time Period:** 5, 55 minute class periods

**Overview:**

This case study will continue the study on the concept of invasive species. In this case, students look at the consequences to invasive species and devise a management plan to help control the problem. Students will work through the case: “Response to Invasion: Managing Spotted Knapweed” written by: Anastasia P. Maines Department of Ecology & Evolutionary Biology, University of Colorado at Boulder, Boulder, CO. Additional supports will be added in order to help students with disabilities to progress through the case study with a relatively high level of independence.

This case study may be accessed from the National Center for Case Study Teaching in Science found here: [http://sciencecases.lib.buffalo.edu/cs/](http://sciencecases.lib.buffalo.edu/cs/). For this case study students will need to read closely the multiple page case study and will then have to answer a series of provided questions. Additionally, students may need to conduct research in order to answer the questions completely. Students will present their answers to the questions to the class in the form of a presentation (PowerPoint, Prezi, etc.)

Given that this case study is lengthier in its reading content, the teacher may wish to complete a prior lesson on reading closely for details and coding the text. Students will then complete the close reading within their cooperative learning groups or the teacher may wish to complete this portion as a whole class. To help make this case study accessible to all students, additional graphic organizers and resources will be added to facilitate the problem solving process.

Furthermore, since this is the last case study presented in this unit, the number of scaffolds will be reduced. For this particular case study, students with disabilities will not be provided with a step-by-step guided handout. Students will continue to work in cooperative learning groups and will be provided with graphic organizers.

**Standards:**

7.1b Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils,
control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and non-living environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

**Big Ideas:**

- What is an invasive species?
- Identify several known invasive species found within the United States.
- What impact do invasive species have on native ecosystems?
- How do invasive species make their way into native areas?
- Identify both the pros and cons to invasive species

**Scaffolds used:**

- Cooperative Learning groups
- Group roles
- Graphic organizers
- Whole Group discussion

**Teacher notes for implementation:**

Prior to starting this case study teachers may wish to include an explicit teaching lesson on close reading. In this case study students will be required to read an information rich case study which will serve as the foundation of their research process. Students will use the case study to help direct them in the research necessary for answering the provided questions. Therefore the students will need to read the case closely to identify the facts, develop questions and formulate the problem statement.

At teacher discretion, students may closely read the case study as a whole group facilitated by the teacher or they may read it in pairs within their cooperative learning groups with a final whole group discussion once the case has been closely read. After considering a specific population of students for whom this project was intended for, this specific project will include a whole class close reading and discussion of the case study. Students will then utilize the large group discussion to brainstorm their facts, questions, next steps and problem statement within their small cooperative learning groups. Prior to initiating the case study the teacher should carefully determine heterogeneous groups for the case study.
Materials and resources needed:

- Printed case study and questions: *Response to Invasion*
- Facts, questions, next steps and problem statement graphic organizer
- Annotation bookmarks
- Whole group discussion

Lesson Plans:

Day 1:

1. The teacher should remind the class that they will be continuing their study on invasive species. This time they will be specifically looking at the consequences of invasive species. Teachers should have students complete a “Ticket in the Door”: What do you believe to be the negative consequences of *invasive species*? The teacher quickly collects and shares responses with the class. The teacher will lead a brief discussion and as a class the students will brainstorm a list of consequences.
2. Next, the teacher should introduce the case study and assignment sheet which will include the final presentation guidelines.
3. The teacher briefly reminds the students of the close reading procedure and the codes that they will use in order to annotate the text. The teacher reminds students that annotate means to code and to take notes on the text itself.
4. Students start by silently reading through Part I – Introduction to Spotted Knapweed. Students should just read at this point.
5. The teacher then reads part one of the case study in its entirety to the class. Then the teacher will re-read the case asking students to annotate the text as they follow along. Students should use the following codes: F= facts presented, = questions I have/ I need more information (Students should write questions they have in the margins) P= the problem *= any information that might be critical or should be considered when solving the case. For students with disabilities, it may be helpful to have a book mark with these annotation codes, to use while reading. Furthermore, the teacher should remind students to box unfamiliar words. Some words students may have difficulty with include: *infestation, noxious, eradication, herbicides, monoculture, herbivores, diversity, palatable, forage*. Depending on your population of students, you may decide to give the definitions to these words up-front or you may have students take time to look up the meaning of these words.
6. Teacher leads a large group discussion on what students annotated any why.

Day 2:

1. Today students will divide into their pre-determined cooperative learning groups. Students will select their role and review their responsibilities.
2. Students will start by re-reading the case study and making an additional annotations
3. Students share out additional annotations
4. Students complete the following facts, questions, and next steps graphic organizer. The recorder will record responses on chart paper.
5. Depending how the groups are working, the teacher may decide to pull the group back for a final discussion of their facts questions and next steps or the students may move forward with defining the problem statement.
6. Students use the following graphic organizer to help them arrive at their problem statement. Some students may not need this graphic organizer at this point.
Defining the Problem Statement

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

Accessed from:

http://greenappleproject.com/pbl/sample/high-school
7. Students should begin by answering the three presented questions within part 1 of the case study in their cooperative learning groups.

Day 3:

1. Today students continue to answer the questions presented in part 1. The teacher circulates to monitor student progress.

2. When everyone is ready to move on the teacher pulls everyone back for a whole group discussion on part 2.

3. Part 2 requires students to read an analyze graphs closely in order to make conclusions based on evidence. Since this is a relatively new experience for students up until this point, the teacher should facilitate this as a whole group discussion with intermittent cooperative learning group work. For example the teacher will start out by reading the introduction and discussing the graphs for question 1. Then the students break into their learning groups to discuss the findings and answer the question pertaining to that graph. The teacher then pulls the students back together and discusses their answers. This allows the teacher clear up and misunderstandings. The teacher repeats this process for evidence/questions 2-6.

4. As a “ticket out the door” groups will need to answer the summary questions for part and submit one copy of their answers to their teacher.

Day 4:

1. Today the teacher starts by wrapping up part 2. Students should answer the summary questions in their cooperative learning groups if they haven’t done so already. The students hand these into the teacher for review. Once this step is completed, then the groups may move on to part 3.

2. Students closely read part 3 in their cooperative learning groups and answer the accompanying questions.

3. The teacher brings the students back together to discuss the findings for part 3. Then she introduces the culminating task described in part 4.

Day 5 and 6: Presentation work days

1. Students use these two days to work on their culminating writing assignment. Instead of writing a paper, the students will address the major requirements through the use of a PowerPoint presentation.

2. Over these two days the teacher should check in with individual groups to monitor progress towards completion.
3. Students complete a “ticket out the door” assessment on invasive species.

Day 7: Presentation day

1. Today each group will present their findings by giving a 10-15 minute presentation

Day 8: Debriefing

1. Students meet in their cooperative learning groups and complete presentation rubrics for each group and then complete participation rubrics for themselves and their group members.
2. Students then begin debriefing on the presentations that they saw. This should be a discussion within their cooperative learning groups. Some students may need to use the following graphic organizer to record their thoughts and ideas.
Implementing the Solution

1. Record the key points of the “master solution” compiled from all the presentations.

2. How will your group implement its part of the master solution? What do you need to apply the solution in real life?

3. What obstacles did you encounter while implementing the solution?

4. What adaptations were necessary?

5. How effective is the solution so far? How do you know?

6. What additional steps or new solutions will you use to reach the desired outcome?

Accessed from:
http://greenappleproject.com/pbl/sample/high-school

3. The teacher then wraps up the case study by facilitating a discussion based on the above handout “Implementing the Solution”

Student handouts necessary for this case study will be found on the following pages.
**Annotation bookmarks**

*(Photo copy and cut one for each student)*

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# Facts and Questions

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Defining the Problem Statement

Defining the problem clearly and concisely in your own words is one of the most important steps in solving a problem. Answer the following questions to help you identify the problem. Refer to what you know, what you need to know, and your ideas as previously recorded.

A. What is the overriding issue or problem?

B. What are the conflicting conditions that a good solution must satisfy?

C. Complete the following statement, summarizing your answers above. This is your problem statement.

How can we (see A above)...

in such a way that (see B above)...

Accessed from:

http://greenappleproject.com/pbl/sample/high-school
Ticket Out the Door Assessment: Invasive Species

Name: _______________________________                       Date: ________________

**Directions:** Using complete sentences, answer the following questions related to the concept of invasive species.

- What is an invasive species?
- Identify several known invasive species found within the United States.
- What impact do invasive species have on native ecosystems?
- How do invasive species make their way into native areas?
- Identify both the pros and cons to invasive species
Assignment Sheet for Part 4

Your Task: Based on your work completed during the case study: Response to Invasion: Managing Spotted Knapweed, you will need to address the following questions in PowerPoint presentation or other teacher approved format.

Questions/components that must be addressed in your presentation:

___1. Description of your experimental design for controlling Knapweed

___2. Justification of your design including evidence from part II

___3. Explanation of your devised plan might affect 2-3 stake holders

___4. Additional references you may have used.

___5. Make sure your presentation is visually appealing.
Implementing the Solution

1. Record the key points of the “master solution” compiled from all the presentations.

2. How will your group implement its part of the master solution? What do you need to apply the solution in real life?

3. What obstacles did you encounter while implementing the solution?

4. What adaptations were necessary?

5. How effective is the solution so far? How do you know?

6. What addition steps or new solutions will you use to reach the desired outcome?

Accessed from:

http://greenappleproject.com/pbl/sample/high-school
References


Chapter 5: Appendix

Appendix A: Literature Review

<table>
<thead>
<tr>
<th>Question</th>
<th>What You Might Have Observed</th>
<th>What Is Going On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you see the production of a gas?</td>
<td>Bubbles from mixing</td>
<td>The gas is a product formed from the two substances reacting.</td>
</tr>
<tr>
<td>Did you feel or collect a temperature change?</td>
<td>The container got warm or if a temperature probe was used there was a change in reading.</td>
<td>Chemical energy is being released (in the form of heat) or being removed (cold)</td>
</tr>
<tr>
<td>Did you see a precipitate form?</td>
<td>Clear liquid would become cloudy. In the case of two liquids, a solid suddenly formed.</td>
<td>Two things come together to make something that is not able to be dissolved in the liquid.</td>
</tr>
<tr>
<td>Did you see a color change?</td>
<td>Color appears when two colorless liquids were mixed or colored materials become colorless or one color changes to another.</td>
<td>Materials are combining in such a way that it affects how much energy it takes to move electrons around.</td>
</tr>
</tbody>
</table>

Note: Not the best indicator

Graphic Organizer
Appendix B: Project Design

Roles and Job Descriptions

Secretary:
Record notes from posters, maintain accurate notes on group progress, and participate in brainstorming

Time Keeper:
manage the groups use of time, politely let each partner know how much time they have left to complete their task, monitor the group’s ability to stay on task, participate in brainstorming
**Director:**

Make sure all of the jobs are assigned in the group, try to make sure everyone gets a chance to speak during the brainstorming session, participate in brainstorming.

**Recorder:**

Label brainstorming posters “Facts and Questions,” record responses during brainstorming sessions, participate in brainstorming.
### Rubrics

#### Presentation Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td>Presentation clearly demonstrates a thorough understanding of the “big ideas” in regards to the topic of water pollution</td>
<td>Presentation demonstrates a basic understanding of the “big ideas” in regards to the topic of water pollution</td>
<td>Presentation demonstrate a minimal understanding of the “big ideas” in regards to the topic of water pollution</td>
<td>Presentation lacks understanding of the “big ideas” in regards to the topic of water pollution</td>
</tr>
<tr>
<td><strong>Evidence</strong></td>
<td>Presentation provides 5+ pieces of evidence to support their proposed problem and solution</td>
<td>Presentation provides 3+ pieces of evidence to support their proposed problem and solution</td>
<td>Presentations provides less than 3 pieces of evidence to support their proposed problem and solution</td>
<td>Presentation does not contain any evidence to support the proposed problem and solution</td>
</tr>
<tr>
<td><strong>Problem Solving Skills</strong></td>
<td>Presentations show superior problem solving skills as demonstrated by strong rationale for the proposed solution and alternative solutions to correct the problem; causes and solutions are sound and reasonable</td>
<td>Presentation shows basic problems solving skills as demonstrated by a basic rationale for the proposed solution and minimal alternative solutions to the problem; causes and solutions are reasonable</td>
<td>Presentation shows weak problem solving skills as demonstrate by an incomplete rationale for the proposed solution. No alternative solutions are provided. Causes and solutions are unclear</td>
<td>Presentation shows little to know problem solving skills as demonstrated by a lack of rational for the proposed solution. No alternative solutions are provided. Causes and solutions are not reasonable for the given case study</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>Presentation is well organized, stating the problem, evidence, proposed</td>
<td>Presentation is organized, stating the problem, evidence, proposed</td>
<td>Presentation is organized but is lacking one of the following: stating</td>
<td>Presentation lacks organization and is missing more than one key</td>
</tr>
<tr>
<td>Participation</td>
<td>All group members participate an equal amount during the presentation</td>
<td>Most group members participate an equal amount during the presentation</td>
<td>Some group members participate more than others during the presentation</td>
<td>Some group members do not participate in the presentation</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>Overall presentation</td>
<td>Presentation is creative, attractive and appealing and free of errors. Participants incorporate the audience in their presentation</td>
<td>Presentation is creative, attractive and appealing with minimal grammatical errors</td>
<td>Presentation is appealing but contains moderate grammatical errors</td>
<td>Presentation lacks creativity and is very simple. Presentation contains many grammatical errors.</td>
</tr>
</tbody>
</table>
# Project Effort and Participation Rubric

**Evaluation for:** _______________________________

**Evaluator:** ___________________________________

<table>
<thead>
<tr>
<th>Goal</th>
<th>4 Points</th>
<th>3 Points</th>
<th>2 Points</th>
<th>1 Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal Work</td>
<td>Did a full share of work or more and performed his/her assigned role</td>
<td>Did an equal share of work and performed his/her assigned role</td>
<td>Did almost as much work as others and did not always complete his/her assigned role</td>
<td>Did little or no work and did not complete his/her assigned role</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Took an initiative in helping the group get organized</td>
<td>Worked agreeably with partners</td>
<td>Could be persuaded to cooperate</td>
<td>Did not cooperate</td>
</tr>
<tr>
<td>Participation</td>
<td>Provided many ideas</td>
<td>Participated in discussions and made some suggestions</td>
<td>Listened to others but offered few suggestions</td>
<td>Seemed bored with the discussions and offered no suggestions</td>
</tr>
<tr>
<td>Support</td>
<td>Assisted other partners</td>
<td>Offered encouragement to other partners</td>
<td>Seemed preoccupied with own project</td>
<td>Took little interest in others’ projects</td>
</tr>
<tr>
<td>Communication</td>
<td>Clearly communicated ideas</td>
<td>Usually shared ideas</td>
<td>Rarely expressed ideas</td>
<td>Never expressed any ideas</td>
</tr>
</tbody>
</table>