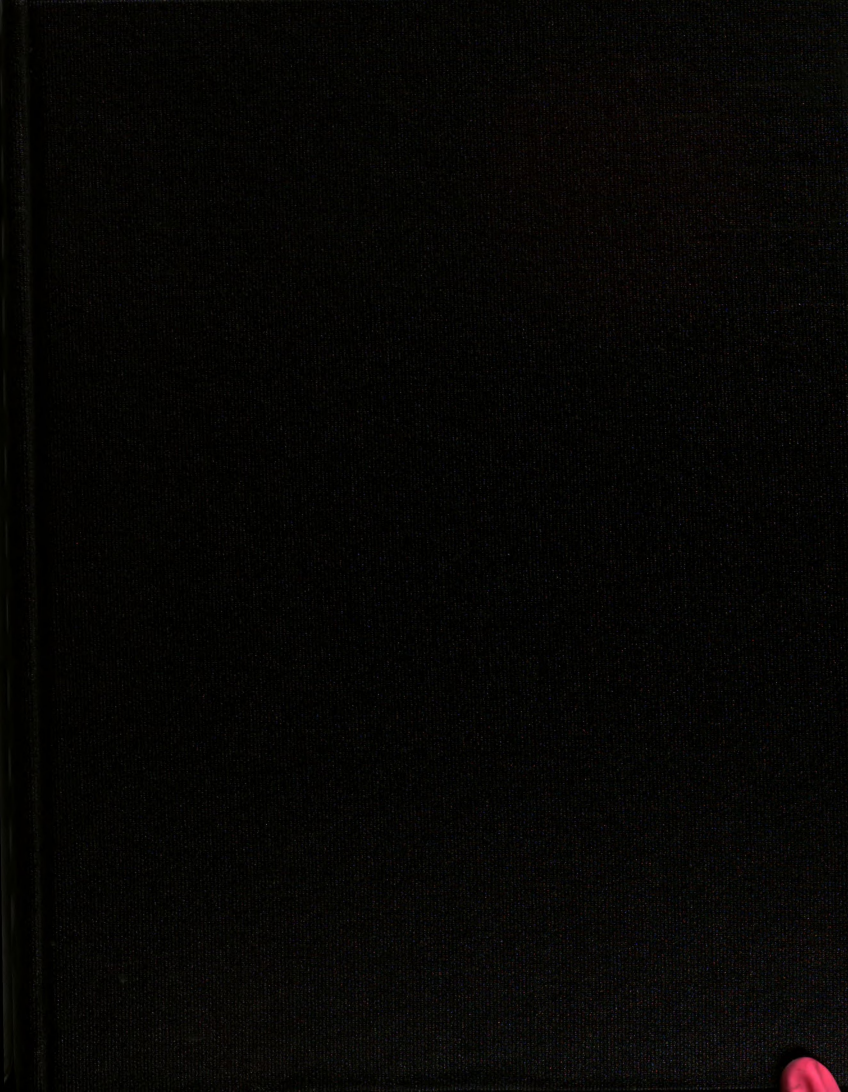




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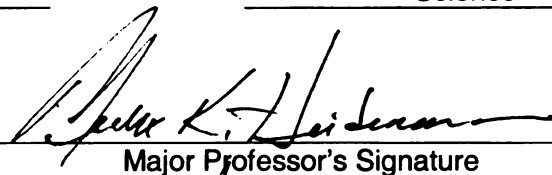
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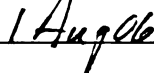
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**EFFECTS OF USING A LAYERED CURRICULUM FORMAT OF INSTRUCTION IN
A HIGH SCHOOL ENVIRONMENTAL SCIENCE ENERGY UNIT**

By

Anne Jeannette LaSovage

A THESIS

**Submitted to
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ABSTRACT

EFFECTS OF USING A LAYERED CURRICULUM FORMAT OF INSTRUCTION IN A HIGH SCHOOL ENVIRONMENTAL SCIENCE ENERGY UNIT

By

Anne Jeannete LaSovage

During the 2005-2006 schoolyear, I implemented a differentiated energy unit in my high school environmental science class in order to increase student motivation, mastery of content and learning retention. The format of the unit was based in part on the Layered Curriculum® model of Kathie Nunley and incorporated student choice, levels of learning, and assessment in the form of oral defenses. Activities for the unit were designed to appeal to multiple intelligences and learning styles.

The hands-on aspects of the unit were a success, as shown by student engagement and perceived enjoyment. Pre- and post-test scores indicated improvement in most content areas. Pre-unit and post-unit survey results also indicate affective changes in student perceptions of relevance of unit content.

Choice was named by students as a positive feature of the unit and could be interpreted as a positive influence on motivation. Motivation did appear to improve in the beginning of the unit, but waned as the unit progressed due to a variety of factors specific to the unit (for example, timelines) as well as general aspects of the student population (for example, intrinsic motivation of students).

Overall, I would consider repeating this unit in this format with some modifications.

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To my instructors from the Department of Math and Science Education, in particular Dr. Merle Heidemann and Dr. Chuck Elzinga: It is with sincere gratitude that I thank you for presenting such valuable learning opportunities and for making all that hard work so very worthwhile.

I would like to also thank my cohorts from the Biological Sciences degree program. It has truly been a pleasure to know and work with you. I consider you friends as well as colleagues. Not only do I value the learning we did together, but I thank you for making the process so much fun.

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INTRODUCTION

RATIONALE FOR THE STUDY

For the past several years I have taught the Environmental Science course at Southfield-Lathrup High School in Lathrup Village, Michigan. During the 2003-2004 and 2004-2005 schoolyears, I was dissatisfied with the structure and delivery of my energy unit in this course. My qualitative observations were that my students did not engage with the unit, were not interested, and learned only minimally the objectives that I intended them to learn.

In contrast, I felt my unit on waste had been a success, as it traditionally had been. In my informal comparison of these two units, I noted a few key differences that might explain the disparate results. First, the issues of waste were easily made relevant to students, but the issues of energy were not. As my hook to open the energy unit, I was using articles about the California blackouts of 2001, which had in previous years made the study of energy seem relevant to students. However, I was now finding that these events were beyond the memory of most of my students and thus had little bearing.

Second, the format of the waste unit involved a great deal of kinesthetic learning and a final project which allowed student choice and action beyond the classroom. The energy unit, in contrast, was quite traditional, with lecture, reading and memorization as the primary pedagogy. Although students built solar ovens, the hands-on and laboratory aspects of this unit were limited to that. Real-world application also was not obvious.

The third difference noticed between the energy and waste units was that while not a novice, I was not as confident or bold in instructing the energy unit as I was in waste instruction. While this aspect of the unit was improved between 2004 and 2005, I still wanted to revise several other aspects. In particular, I wanted to increase lab experiences and possibly increase choice to mimic the positive results of the waste unit.

SPECIFIC GOALS FOR NEW UNIT

In addition to the energy content objectives, specific goals with a new energy unit were to:

- Increase student motivation and engagement by providing student choice
- Increase relevance and hands-on activities in the unit
- Allow students to learn and demonstrate learning through multiple intelligences
- Increase authentic learning by holding students accountable for their learning
- Increase student mastery of content
- Increase retention of learning

Also, I kept in mind the overall goals of the course, including that “students will become more skilled in making and defending informed decisions.”

COURSE BACKGROUND AND STUDENT INFORMATION

At the time of this study, graduation requirements at Southfield-Lathrup included three credits (six semesters) of science. Typically, students are scheduled in science for all four years. Environmental science is a common senior class, although juniors do enroll and occasionally the population will include a few tenth graders. Students enrolled in environmental science generally do not enroll in Advanced Placement courses.

The average grade point of students in this study for the semester of the study was 1.97 on a four-point scale. The range for GPA was from a low of 0.333 to a high of 3.222 with only one student having a GPA of 3.0 or higher for the semester of the study. As an indicator of the self-view of students in this class, when a sample of students in the class self-reported efficacy in science, about a third believed that they could do well in a science class, a third did not believe they could do well, and approximately a third indicated a neutral response.

The primary text used in the environmental science class is Holt's Environmental Science and the course is divided into two semesters which may be taken consecutively or independently. It is not required to take both semesters, although most students do. While the courses complement each other, they cover different topics and chapters. The first semester topics have a predominant focus on ecology and conservation. Second semester topics place emphasis on urban issues and human-caused problems in the environment. Both courses stress improving student confidence and competence in making and justifying decisions which will affect their environment. Units for the second semester are Population, Energy, Water, Waste and Air/Atmosphere.

DEMOGRAPHICS OF SOUTHFIELD-LATHRUP HIGH SCHOOL

Southfield-Lathrup High School is one of two high schools in the Southfield Public School District. The district draws from Southfield, Michigan (a suburb directly north and adjacent to Detroit) and Lathrup Village, Michigan, a small community geographically encompassed by the city of Southfield. The district is in Oakland County, Michigan and has in the past allowed open enrollment, meaning students out of the district but within Oakland County may attend as space is available. In addition to this legally serviced population, there is some residency fraud by our students although a documented estimate is not available. (Students in conversation have estimated that 30% or more of their classmates are not legal residents in the district.)

At the February 2006 count day, the district had a total of 9800 students in kindergarten through twelfth grade an additional 237 students enrolled in pre-kindergarten. The student population of Southfield-Lathrup High School was 1697 at the February count, just slightly larger than the sister school which had 1548 students.

Demographically, the school population is 53% female and 47% male. The racial/ethnic demographics are as follows: American Indian/Alaskan <1%, Asian 1.5%, Hawaiian <1 %, Black 87%, White 8.5 %, and Multiethnic 1.8 %. Overall, fewer than 0.28% of students are eligible to receive free or reduced lunch. Southfield-Lathrup has a strong English Language Learner program which serves a number of international students. The school generally has a dropout rate that is slightly lower than the state average. Between eighty and ninety percent of graduates are accepted to two and four year colleges and universities or technical or business schools (class of 2005 was 84%).

LITERATURE REVIEW

LAYERED CURRICULUM AND MULTIPLE INTELLIGENCES

During 2003-2004 schoolyear, the science department chair and others in my building had been introduced to and tried out Layered Curriculum™ units in their classes. While the planning of a layered unit is very intensive, it seemed that the format might help achieve some of my goals for the energy unit.

Layered Curriculum is a form of pedagogy trademarked by Kathie Nunley of Utah in the 1990s. The format of instruction attempts to meet the needs of differentiated classrooms by allowing a great deal of student choice, personal accountability for students, and an emphasis on reaching students within their preferred learning styles.

A layered curriculum unit consists of three tiered layers: C, B and A which represent both the level of thought and the letter grade a student can earn by completing that part of the unit. The C layer involves basic knowledge and understanding. The B layer deals with applying information learned in the C layer and problem solving using that information. A layer activities involve the more complex thought processes of critical thinking and analysis. Each layer of the unit is a prerequisite for the next layer.

Student accountability is a cornerstone of layered curriculum. The way Nunley incorporates accountability is through the use of “oral defenses” to earn points. In an oral defense, a student meets one on one with the instructor to “defend” an assignment. This generally involves the teacher asking questions about the assignment and the student answering although the structure of the oral defense can be different when defending different types of assignments.

Oral defenses promote accountability as well as reduce cheating. Even a student who copies a paper still has to know the material in order to defend and earn points for it. This supports Nunley's view that teachers should "give credit for actual learning, rather than for doing" (Nunley, 2004).

Nunley's motivation to design her format of instruction came out of a desire to reach a greater percentage of learners in her diverse classroom. Diversity can refer to any set of conditions which make the members of a certain community different from one another. Conditions may include religious background, family structure, age, language spoken, or socioeconomic status. Even in a seemingly monoculture classroom, there are differences among students in terms of family background, popularity, and even self-esteem. Educational research makes diversity even more relevant to the classroom; it is now widely accepted that how students learn and express learning is also a basis for diversity.

Historically, differences between learners have been conceptualized in terms of differences in ability—those who were successful in school were more intelligent than those who were not. This "global intelligence" idea was challenged as observers realized that students can and do "exhibit different levels of achievement in different subjects" (Muijs and Reynolds, 2001).

It was such observation that caused Howard Gardner to develop his theory of multiple intelligences in the later part of the twentieth century (Muijs and Reynolds, 2001). Gardner initially outlined seven intelligences. These were verbal-linguistic, interpersonal, musical-rhythmic, intrapersonal, bodily-kinesthetic, mathematical/logical

and spatial. He later added another intelligence, naturalist. For more information, see Appendix A.1 and the Multiple Intelligence Survey (Appendix D.9).

Gardner believed that although many people have one or two dominant intelligences, individuals are not limited to one intelligence. Rather, every individual reflects some amount of each intelligence and their relative preference can change throughout an individual's lifetime (Jensen, 1996).

Gardner's description of each intelligence provides a way to individualize instruction for improved understanding. For example, Jensen (1996) suggests that providing logical-mathematical students with computer time, gadgets to take apart or fix, museum trips, riddles and calculation activities will likely connect with their intelligence. In contrast, art, changing locations, using large pieces of paper, videos, map-making and sculpture are likely to appeal to those learners with spatial intelligence.

Multiple intelligence theory also inspires ways to assess students that are more valid because they utilize the strengths of that individual (Fetsco, 2005). As teachers, we want to know what students learn, but we often test how well students can utilize a specific intelligence to express it.

Many schools appear to have had success in incorporating the theory of multiple intelligences into their instruction and assessment. As an example, when Jan Greenhawk's school in Maryland (Greenhawk, 1997) modified units to incorporate multiple intelligences, teachers noticed that in general, "students became more self-directed and seemed more confident in trying out new skills." Additionally, when given choices in how to research and present their learning, "the students seemed more willing and able to do the research."

Gail Hickey (2004) documented several examples of success stories in her study of five middle school teachers who implemented multiple intelligences in their classes. Benefits included students being more actively engaged, retaining information for longer periods of time and demonstrating a deeper understanding of content. One teacher commented that one of his more talkative students did very well when she used her interpersonal intelligence on an interview project. The student was “doing what she normally or comfortably likes to do” but it was directed towards achieving a learning goal instead of becoming an unharnessed distraction in the classroom.

Among Hickey’s conclusions were that student choice is an integral part of multiple intelligence based learning but that not all students embrace choice equally: A few students who were considered gifted and talented asked, “Why don’t you just give us a test?” (Hickey, 2004).

Whether the use of multiple intelligences proves useful in the classroom depends on the goals of that class or lesson. Latham (1997) states, “If the only goal is to improve test scores, multiple intelligences may work no better or worse than other theories. But if the goal is to reach as many students as possible and to acknowledge, celebrate and refine their talents, then multiple intelligences appears to hold great promise.”

LEARNING STYLES

Multiple intelligences is one construct by which to understand a learner; learning style is another. David Kolb (1984) has proposed that an individual’s learning preference can be related to a four-stage learning cycle which progresses from concrete experience

through reflection, abstract conceptualizing and finally experimenting (Appendix A.2).

Learners can be classified as accommodators, assimilators, convergers and divergers (Appendix A.2) based on how they choose to approach a task and transform the experience into something useful (Chapman, 2006).

Muijs and Reynolds (2001) describe additional aspects of learning styles as proposed by other theorists, including inductive and deductive learning and global and sequential learners. The authors also compiled this list of styles from several sources:

Visual – learn through seeing

Auditory – learn through hearing and listening

Tactile/kinesthetic – learn through touching and moving

Print-oriented – learn through reading

Interactive – learn through discussions and group activities

Olfactory – learn and remember when smell is used during learning experiences

(For further elaboration on learning styles, please refer to Appendix A.2.)

While some modern theorists believe that a learner's preferred or default learning style that is more or less fixed, other theorists imply that preferences can change over the lifetime of an individual or even at different times of the day (Jensen, 1996). While agreeing that learners do indeed have preferences, Jensen (1996) contends that, "The human brain does not just have a single 'learning style.'" In fact, he states, "The whole notion of learning styles becomes irrelevant when we consider the variety with which the brain works." To support this second statement, Jensen claims that learning happens:

1. In context – including conditions of the physical and emotional environments
2. With input preferences – how information is presented

3. By processing it– e.g. global, sequential, analytical, left- or right-brain
4. Then reacting to it – e.g. pattern-finding, reflecting, acting

What does an understanding of learning styles contribute to successful classroom pedagogy? Throughout the literature, there is strong implication that many students who are not successful in school are simply not experiencing learning opportunities in a way that suits them (Jensen, 1996; Muijs and Reynolds, 2001; Henson and Eller, 1999). As Jensen (1996) states, “Many learners who seem apathetic would be very enthusiastic if the learning was offered in their preferred learning style.”

Knowing about learning styles, it seems, should help an educator to streamline one-on-one instruction. However, after reviewing the available literature, Muijs and Reynolds (2001) concluded that, “while a number of these tips [about teaching to the learning style] make intuitive sense there is very little research that suggests that teaching to different learning styles actually improves students’ achievement.” The authors further cite the research of Stahl in saying “One cannot reliably measure children’s learning styles and even if one could, matching children to reading programs by learning styles does not improve their learning.”

How do we reconcile the intuitive drive urging us to utilize learning styles even though the literature (albeit limited) shows no correlation to “teaching to the style” and student success? Jensen (1996) and Muijs and Reynolds (2001) suggest that offering learning with variety and choice will automatically cater to the styles of different learners, with variety allowing for exposure to many learning styles and choice allowing students to pick the style that best suits them at the moment.

MOTIVATION

Motivation is related to learning in important ways. Wiseman and Hunt (2001) indicate among other things, that motivation “enhances cognitive processing” and “leads to improved performance.” Motivation also improves engagement, which can lead to increased learning (Fetsco, 2005). While understanding and applying multiple intelligences and learning styles can positively influence an educator’s approach, to maximize student learning, motivation must also be addressed. One of the reasons for designing a new energy unit is to increase learning; if motivation can improve, it follows that the learning success of students should improve as well.

What is motivation? Sources differ in their definitions (Appendix A.3), but there is general agreement that motivation is an internal drive that causes action or inaction on the part of an individual. Intensity of student motivation can be observed in certain aspects of student behavior, including the choices students make, the effort they invest to achieve a goal, the frequency or intensity of certain actions and the persistence to which an objective is pursued (Fetsco, 2005).

Motivation itself is categorized into two forms. Motivation as a “means to an end,” or that depends on external rewards or incentives such as grades, accolade or money is considered extrinsic motivation (Wiseman and Hunt, 2001). An extrinsically motivated student might ask, “How many points is this worth?” before deciding whether to complete an assignment. Often, when the reward is removed or loses value, the behavior that it promoted comes to an end. Externally motivated students may be less likely to participate in rigorous learning activities of their own volition (Jensen, 1996).

Further, Bigge (1971) cautions that, “When a learning goal is extrinsic, it is obvious that once the goal is met there ceases to be any point in remembering the learned material.”

In contrast to extrinsic motivation, intrinsic motivation is “motivation to become involved in an activity for its own sake” (Wiseman and Hunt, 2001). Intrinsic motivation has incentives that come from within an individual. These may be apparent, such as the enjoyment of pursuing a hobby, or they may be less obvious, such as joining a sports team to meet a socialization need. When learning is intrinsically motivated, retention, understanding and transfer are increased (Bigge, 1971).

Relevance, choice, varied learning conditions, interest, and fun can positively influence motivation. Past experiences, classroom structure, and student self-view also impact motivation either positively or negatively. But what ultimately affects student motivation in your own classroom? Fetsco (2005) states that “students will be motivated in your classroom to the extent that your plans allow them to meet and gratify their personal needs and motives.”

A need is “a physical or psychological condition that a person must maintain to stay healthy” (Fetsco, 2005). Abraham Maslow described several needs universal to the human condition. He further arranged these needs in a pyramid shaped hierarchy to describe their relationships (Figure 1; Appendix A.4).

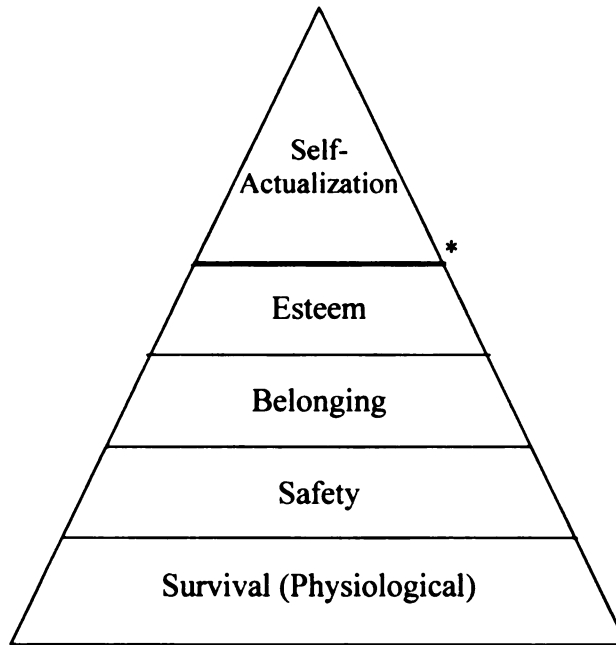


Figure 1: Maslow's Hierarchy of Needs

* Some versions of the hierarchy include Aesthetic and Intellectual Needs here.
For more information, please see Appendix A.4.

Maslow believed that needs higher on the pyramid could not be satisfied until the subordinate needs were filled. Henson and Eller (1999) support this in terms of motivating students within school setting. “If students do not feel secure in the classroom, they will not be motivated to pursue a higher-level need for knowledge.” Tangibly, we also see evidence of Maslow's hierarchy in schools. Regardless of a teacher's attempts, if a student is hungry, fearful, or has just been kicked out of her house, he or she is not going to have academic learning as a priority. Teachers of adolescents can also see that esteem needs, particularly the need for peer esteem, are often much stronger than intellectual needs.

In contrast to needs, motives are habits or tendencies to seek out and enjoy certain activities or accomplishments. Whereas needs are innate facets of the human condition,

motives are learned. Individual learners will therefore have different motives because they have different life experiences. Once acquired, motives can be considered a relatively stable characteristic of a person and have the ability to influence a person's performance in a wide variety of situations. Understanding the basis for motives is vital to an educator because motives affect how students respond to the classroom and to the instructor (Fetsco, 2005).

Two examples of motives are the motive to achieve and the motive to avoid failure (Fetsco, 2005). According to achievement motivation theory, the relative strength of these two motives in an individual, along with perceived likelihood of success on a particular task and the value of such success, will engender certain response choices from that individual.

Typically, students with a strong motive to avoid failure need a level of certainty in their surroundings (Fetsco, 2005). This can be a significant drive, even to the point that these students will sometimes choose to fail completely if they feel that a reasonable attempt will not produce acceptable results. Ironically, some students who fail because they don't attempt assignments are actually acting on a motive to *avoid* failure. The need for certainty outweighs the shame of attempting a task and then failing.

In some ways, layered curriculum provides certainty to learners. Students in Nunley's class know exactly what grade will be earned based on the C, B, and A level organization. In other ways, however, layered curriculum provides a great deal of uncertainty. Students who have difficulty choosing tasks may be overwhelmed and see the format as guaranteed failure. These students may decide before they even begin that inaction and avoidance are the safest choices.

Learners who have a stronger motive to achieve are more likely to select more difficult tasks and value the learning potential they provide. Also, they are more likely to persist in the face of limited success. In contrast, students whose motive to avoid failure is stronger are likely to select less challenging tasks and in the face of failure are likely to give up. Henson and Eller (1999) confirm this, indicating that students low in achievement motivation will respond to failure with even lower motivation, although they do suggest that teacher actions can affect motives (Appendix A.5). Given the amount of choice in a layered curriculum, student motives may influence their interaction with the unit.

Another attribute of personality that affects motivation and response to situations is how much control an individual feels he or she has over his or her circumstances. Weiner's attribution theory addresses the perception of students in three dimensions: the locus of control, stability, and controllability (Henson and Eller, 1999).

Locus of control, the most relevant to this discussion, deals with whether individuals believe they are responsible for their own successes or failures. Individuals with an internal locus of control are likely to believe that poor or good performance on a test is due to ability, effort or some facet of themselves which allows them to be good test takers. In contrast, students with an external locus of control are likely to believe that performance is due to luck, how easy or difficult the task was, or other external features, including bias on the part of the test grader. When receiving a poor test paper, a student with internal locus of control might say, "I should have studied harder," while a student whose locus of control is external might say, "This test was too hard for anyone to pass."

One can see a causal relationship with student motivation. People with a strong internal locus of control tend to be more persistent at tasks. In contrast, people with a highly external locus of control feel more powerless and are likely to stop attempting tasks at the first indication of difficulty. (For more discussion on the other two factors, please see Appendix A.6.)

Repeated lack of success is another significant contributor to reducing motivation. Students who continually experience failure may develop what some psychologists call “learned helplessness” (Wiseman and Hunt, 2001; Fetsco, 2005; Taylor and Nolen, 2005). In this state, students have come to believe that studying does them no good and that they are helpless to do well no matter what effort they put forth. The end result is that students reduce both their interest and effort in the subject (Taylor and Nolen, 2005).

This does not mean that all students should always be successful, however. Bigge (1971) states, “For success to be experienced as such, there must be a possibility of failure.” The joy of success can only occur when students have to work for it. What we learn from this is that a balance must be met between challenge and success.

Student perceptions and feelings play a significant role in student motivation (Henson and Eller, 1999). Specifically, a student’s self-concept, self-esteem and self-efficacy can begin a cycle of increased or decreased motivation, fueled by how a student perceives the results of attempting a task. Jensen (1996) states, “Those who learn less often expect to learn less.” Empirically, I have seen examples of this in my own classes. Self-concept, self-esteem and school achievement are elaborated in Appendix A.7.

In addition to student views of self, social, cultural and peer pressure also can sometimes have a negative impact on student motivation. Henson and Eller (1999) state,

“While established institutions, such as the school, work to influence youths positively, youths have their own cultures, and the characteristics of these cultures often conflict with the goals of the school.”

The influence of the environment outside the classroom is beyond a teacher’s control. However, teacher expectation is an important factor in the classroom. Although personal efficacy is a stronger force, if the student perceives that the teacher believes he or she can achieve, there is a positive correlation with increased motivation and success (Muijs and Reynolds, 2001).

Can a teacher truly motivate students? Wiseman and Hunt (2001) suggest that teachers do not motivate, they merely “set the stage” for motivation to occur by managing the learning environment. Learners are more motivated when they perceive the potential for success, when they believe the learning goals are important, interesting and relevant, when learning activities address personal needs and motives, and when variety and choice are offered. A teacher can motivate students inasmuch as he or she can establish learning environments that strive for optimal levels of each of these factors.

DISEQUILIBRIA

Aside from those aspects already discussed, there are other facets of motivation to consider. For example, Bigge (1971), applying Piaget’s theories, states that, “We experience our strongest motivation in situations that are puzzling.” According to Piaget, the brain is constantly searching for order and balance, so called “equilibration.” Disequilibria, or puzzling situations, cause tension, and must be resolved (Bigge, 1971).

Given this, Wiseman and Hunt (2001) believe that a certain amount of disequilibria is actually desirable to encourage students to be motivated. Henson and Eller (1999) concur, stating that, “Students can be motivated to perform well, not only because of rewards such as grades or praise, but because of factors such as interest, curiosity, the need to obtain information or solve a problem or the desire to understand.”

Although some level of tension is essentially required to motivate, too much and you lose. There is a threshold of stress in the learner, past which the motivation is no longer to solve the problem but to avoid it.

In a similar balancing act, the balance between challenge level of an assignment and a student’s skills influences motivation and student success (Wiseman and Hunt, 2001; Henson and Eller, 1999; Appendix A.8). When challenge far outweighs skill, a learner can become anxious and motivation can cease. When skill far outweighs challenge, boredom ensues. The “state of flow” for optimal learning happens when the mix is right between the challenge level of the activity and participant skill level. You know a class has been in this state when the bell rings and students say, “Wow—is it the end of the hour already?”

ANXIETY

Anxiety, defined by Wiseman and Hunt (2005), is a “feeling of apprehension, worry, tension or nervousness.” Anxiety can be either good or bad for student learning, depending on the intensity. Anxiety which causes action is termed “facilitating anxiety” by Wiseman and Hunt (2005). For example, when you are running late in the morning,

the worry of missing your meeting time can cause you to pick up your pace and hurry out the door. Similarly, a small amount of anxiety for students poses a challenge and is a motivating force. If the situation causing the anxiety is perceived as temporary, and students can visualize a way to work through the anxiety, they will be motivated.

Correspondingly, in complete absence of anxiety, students may not be motivated at all

On the other extreme, very high levels of anxiety, so-called “debilitating anxiety” (Wiseman and Hunt 2005), have a negative impact on learning. In times of elevated stress, students may resort to using avoidance behaviors or a number of other responses. Wiseman and Hunt (2005) warn of potentially extreme consequences for debilitating anxiety: “Many students experience levels of anxiety that are virtually paralyzing in terms of affecting their motivation and performance.” The use of oral defenses should be approached with care to avoid the possibility of such anxiety.

CHOICE

Choice is noted throughout the literature as a way to increase student motivation (Wiseman and Hunt, 2001; Hickey, 2004; Nunley, 2004; Taylor and Nolen, 2005).

Choice may influence motivation simply because it increases the potential for student interest. As Jensen (1996) states, “If participants are to be predominately self-motivated, they must be given the opportunity to focus on *their* areas of interest and to participate in activities *they* find interesting.” As well as providing for topic interest, choice can assist in accommodating learning style differences.

Choice may also increase motivation by fulfilling adolescents' increasing needs for autonomy. Researchers agree that using choice to empower students with feelings of control, ownership and responsibility can positively impact motivation (Taylor and Nolen, 2005; Wiseman and Hunt, 2001; Hickey, 2004; Nunley, 2004).

In addition to increasing motivation, choice may also have a beneficial impact on the quality of the learning. Several studies indicate that when students learn on their own, learning is more meaningful than when they learn as a result of others. Additionally, students learning on their own do not need to depend on the teacher for external motivation as often as other students do (Henson and Eller, 1999).

For the reasons described above, layered curriculum might address my goal of increasing motivation as well as learning in the energy unit. However, although choice overall is good, Taylor and Nolen (2005) warn that students sometimes have difficulty when given the opportunity for choice:

“Students who are used to having teachers guide every step in their work may resist taking the risk of self-choice—especially if they have learned that teachers actually have unwritten expectations. In fact, we have found that students’ resistance to self-choice most often comes from experience in school or at home where self-choice has been discouraged or even punished.”

MEMORY AND RETENTION

An awareness of current theories of memory can also help in teaching for retention and true learning. According to Nunley (2004, “Why Hands-on Learning is

Good”) there are two types of memory: semantic and episodic. Semantic memory is that which we set out to remember—facts, dates, processes like addition and subtraction. Episodic memory consists of things that we remember without consciously attempting to do so. Examples of episodic memories are what we ate for dinner last night, our favorite gift on our eighth birthday and the sadness we felt at a funeral of someone close to us. These two types of memories may be formed and stored by separate systems of the brain, the evidence for this being that persons affected with Alzheimer’s disease can lose much of their episodic memory but retain their semantic.

According to Nunley (2004, “Why Hands-On Learning is Good”), the episodic memory is more permanent and more easily accessed than the semantic. It is the reason many adults remember the frog dissection from their biology class but not the stages of meiosis. Nunley uses this as justification to employ as much hands-on learning as possible. Her logic says that activities which target both memory systems likely lead to more retention. Nonetheless, although episodic memory may be more permanent and accessible, the semantic memory has been shown to be more accurate, thus implying a need and functionality for this type of memory.

Jensen (1996) criticizes the typical emphasis on semantic memory in schools, calling semantic memory “a very unnatural way to learn and remember things.” Similarly, Bigge (1971) concludes that natural memory formation (enhanced and intensified by sight, smell, sounds, touch and taste, and motivated by curiosity, novelty and expectations) leads to more retention. He states, “Material that can be learned insightfully, particularly on the level of generalized insight, becomes a permanent part of one’s personality structure.”

To apply this to the classroom, researchers suggest targeting as many memory systems as possible when teaching and learning information; the more senses that are engaged, the less likely the learning will be forgotten. Sensory-rich activities could include field trips, guest speakers, and hands-on learning (Bigge, 1971; Jensen, 1996; Nunley, 2005, “Why Hands-On Tasks are Good”).

OTHER INFLUENCES ON MEMORY

Several other factors likely influence memory, including the emotional state, hormone levels, and intention of the learner, and the learner’s perceived meaningfulness or relevance of the content.

It is commonly understood that students will be interested in and retain learning of content that relates to their own lives (Bigge, 1971; Wiseman and Hunt, 2005). In fact, Bigge asserts that content “will be remembered in proportion to its meaning” even if the delivery of that content is imperfect.

The effects of hormones on memory are also well established in the literature. While some hormonal production and response is not within the teacher’s control, it is sometimes possible to influence hormone production through the classroom environment. For example, laughter and smiling can cause the release of endorphins which have a positive impact on the learner (Jensen, 1996). Conversely, high levels of stress produce other hormones that have been shown to negatively impact learning and recall (Nunley, 2004 “Stress”).

A learner's intention or desire to remember or forget an item or event (whether conscious or subconscious) is a factor in memory and learning retention as well. An extreme case is the "blocking out" of a traumatic event or memory (Bigge, 1971; Fetsco, 2005). Less extreme cases are more common, but also likely deal with stress levels and emotional states or associations. At all times the brain, is selecting and sorting which memories should and should not be retained based on a number of internal and external conditions.

Emotions can impact motivation in other ways. For instance, if a student associates bad feelings with coming to class, he or she may decide not to come to class at all, or if he or she does come, there is likely to be less learning than might occur under more favorable conditions (Fetsco, 2005).

DEMONSTRATING AND ASSESSING LEARNING

If students are motivated and conditions are suitable, learning should take place. It follows that good assessment should allow students to demonstrate this learning. There are many ways to assess what a student has learned. Routman (1999) suggests that we can obtain valuable information about our students and their learning simply by our ongoing interactions and observations of them, pointing out that the root of the word "assessment" is the Latin "assidere" which means to "sit beside someone." However, standardized tests are a more popular form of assessment, especially for college admissions and government data collection. Other forms of assessment range from

observing a student's participation in a discussion, checking spelling words on a spelling test, or evaluating a student's thesis paper.

Assessments and their relative value may differ based on the actual task requested and on the real or manufactured nature of the context and audience. Those which model (or actually are) real life behaviors are sometimes of greater value to both the evaluator and the student. Educational authorities refer to such types of assessment as performance or authentic assessment (Taylor, 2003; Muijs and Reynolds, 2001; Henson and Eller, 1999).

Although educational researchers have competing definitions for authentic and performance assessment (see Appendix A.9), they do agree that such assessments are a good way to measure real learning. Additionally, as Taylor (2003) promotes, this type of assessment often can be used to affect the marginalized student in a classroom (e.g. poor test takers, students with learning disabilities).

Routman (1999) believes these things about meaningful assessment:

- Assessment must promote learning, not just measure it
- A good assessment becomes a learning experience that supports and improves instruction
- The learners are not just the students but also the teachers, who learn something about their students.
- Meaningful assessment interacts and aligns with instruction and has value for the student, teacher, and parent

The use of oral defenses addresses my desire to have more authentic learning and learning retention. Defenses hold students individually and acutely accountable for knowing their information. Questioning students appears to have benefits to students as

well. Specifically, questioning helps students to clarify their thinking, use higher-level thinking skills and problem solve (Muijs and Reynolds, 2001; Routman, 1999).

Students who are used to interactive lessons are more likely to respond to questioning (Muijs and Reynolds, 2001). Thus oral defenses may be out of the comfort level of many students who have been primarily taught in other ways. The phrase, “But I did it, doesn’t that count?” from a student irritated by having to defend work probably stems from a traditional school culture which “has not encouraged students to see the connection between daily classwork and learning” (Nunley, 2004 “Accountability”). Getting students to buy into the idea that grades depend on what they learn and not what they did is a challenge with using oral defenses as a form of assessment.

Using oral defenses to assess also has some caveats when considering student anxiety. TenBrink (1974) cautions:

“The way in which an individual responds to a test (or any other evaluation task) can cause error. For example, a student’s attitude toward a test may influence his score. If he does not care at all, his score will reflect this. If he cares too much and becomes overly anxious, his score will also be in error.”

Similarly, Taylor and Nolen (2005) remind us to be sensitive to learners in all forms of assessment, stating that when assessments are viewed as a way for teachers to control students, students become less enthusiastic and less engaged.

Muijs and Reynolds (2001) suggest that a nonevaluative atmosphere is best for eliciting student response. This of course is less possible to achieve in an oral defense in which the goal is evaluation of student understanding. Nonetheless, the potential benefits of this form of authentic assessment outweigh the challenges.

BACKGROUND INFORMATION ON CONTENT

For something so much a part of our lives, energy is a rather intangible and hard to define term. Colloquially, we use a layman's definition of the term in phrases such as, "Would you like an energy bar?" and "I am just out of energy." By high school, scientifically literate students should know that energy comes in different forms and can be converted from one form to another but cannot be destroyed. Students should be able to list forms such as potential, kinetic and possibly others such as thermal, nuclear, light, electrical, chemical, or radiant.

In fact, all forms of energy can be classified as potential (stored energy) or kinetic (energy of motion). Thermal or heat energy is considered kinetic energy because it is a manifestation of the kinetic energy of individual molecules or particles. Radiant energy, including light, is also kinetic because the electromagnetic waves are in motion. Chemical energy, in contrast, can be a form of potential energy because net energy can be stored in the bonds of chemical compounds.

Each form of energy can be converted and reconverted into other forms. For example, through the processes of photosynthesis plants convert light energy into chemical potential energy. Also, a generator can transform kinetic energy into electrical energy. Braking a car actually converts some of the kinetic energy from the movement of the car into thermal energy on the brake pads. The Law of Conservation of Energy, also known as the second law of thermodynamics, states that no matter how many conversions, the net total energy of a system remains constant.

Energy and its multitude of related topics are studied in all the science disciplines as well as in non-science disciplines (Appendix A.10). In terms of an environmental science class, energy studies have a two-fold emphasis. First is the ecological theme of energy flow through an ecosystem, similar to the study of energy in a biology course. Second is the theme of energy as a natural resource used by humans. How humans utilize energy resources and the impacts of such use is the focus of this thesis.

The content objectives relating to energy in my environmental science class deal with four parts: 1) energy forms, 2) how we produce electricity from various energy sources, 3) pros and cons of our energy use, and 4) personal responsibility and conservation. These objectives are fully described in the Implementation section.

While energy forms are exemplified above, energy sources are the raw materials or natural resources that people harness to convert energy for human use, primarily for conversion to electricity. The nine common energy sources referred to in this paper are fossil fuels, wind, hydroelectric, tidal, nuclear, geothermal, biomass, solar and fuel cell. A brief description of each follows.

Fossil fuels are nonrenewable sources formed from the remains of prehistoric organisms. The three forms of fossil fuels—coal, oil and natural gas—are used to produce an estimated ninety percent of the world's energy needs (Barnes-Svarney, 1995). Of the fossil fuels, coal is the most often used for electricity production in southeast Michigan. More detail is available in Appendix A.11.

Electricity is produced from fossil fuels through the following energy transfers and transformations. First, the fuel is burned, releasing the stored chemical potential energy from the bonds of the fuel's molecules and releasing light and large amounts of

heat (thermal energy). This thermal energy is used to heat water and convert it into steam. The steam becomes the motive force (kinetic energy) to turn a turbogenerator. Essentially, a turbogenerator is a turbine attached to a powerful magnet that turns inside a set of coiled wires. The net result of the relative motion of magnets and wires is the induction of an electrical current, in this case, an alternating electrical current.

This phenomenon of inducing an electric current using a wire and magnet is known as Faraday's law. It is the premise behind electricity production in seven of the nine energy sources. These seven sources differ only in what causes the relative motion of the wires or magnets.

In a manner similar to fossil fuels, biomass uses combustion to release stored energy from chemical bonds. The thermal energy released from burning biomass (or biofuels) can then be used to heat water to make steam to turn a turbine. Geothermal also uses steam to turn a turbine, but the steam is created from water heated by the earth's own heat. Nuclear power also uses steam to turn a turbogenerator. However, the energy to produce the steam comes from fission—the splitting of nuclei, usually of a massive radioactive element such as plutonium.

In the sources described so far, several energy transfers are required to make steam. The next sources also use a turbine and generator, but have fewer energy conversions. Wind power provides the simplest example of electricity generation using a turbine—wind itself turns the turbogenerator. Modern turbines have elaborate gears to maximize the torque provided by a steady wind. Hydroelectric uses the gravitational potential energy of falling water to turn a turbine. Tidal employs water and potential energy in a similar manner. (Incidentally, wave action is also used in some locations.)

The remaining two energy sources do not employ Faraday's law and do not involve kinetic energy. Fuel cells, specifically hydrogen fuel cells, convert chemical energy directly to electrical energy. In a typical polymer electrode matrix (PEM) fuel cell, hydrogen and oxygen react in the presence of a platinum catalyst to form water. Due to the structural design of the fuel cell, the electrons which are stripped from the hydrogen create a voltage potential across the electrodes.

Photovoltaic cells convert light energy directly to electrical energy. Light is absorbed by a semiconductor, usually silicon. Electrons within the cell's matrix are excited, leaving "gaps" which are filled in by other electrons. The difference in electric potential between the top and the bottom of the cell creates a current.

The energy sources themselves can be classified into two groups—those coming from renewable resources and those from nonrenewable resources. (Some references use the term "alternative energies" to describe renewable energy resources.) A renewable resource is defined as a resource that can be replenished in a reasonable amount of time. Wind, sunlight, grain, and trees (if not overharvested) are examples of renewable resources. A nonrenewable resource cannot be replenished in a human lifetime. Fossil fuels are a prime example of a nonrenewable resource. A common misconception of students is that renewable means reuseable. This has traditionally been a difficult misconception to break even though several examples contradict it (Appendix A.12).

A major theme in the study of energy in this unit is that every energy choice has consequences. A partial list of pros and cons of each of the nine energy sources can be found in Table 1. A brief elaboration of two sources, fossil fuels and nuclear power, follows.

Table 1: Pros and Cons of Nine Common Energy Sources

Energy Source	Pros	Cons
Fossil Fuels	- Very dense energy source - Well established infrastructure	- Large carbon dioxide and other air pollution emissions contribute to global warming and respiratory illness - Cause of acid rain - Nonrenewable resource
Nuclear	- Very dense energy source - No air pollution	- Plants are very expensive to build and maintain - Fuel supply is nonrenewable - Safety concerns - No long term storage for waste
Wind	- Clean/no air pollution/no waste - Renewable - Energy payback is good	- Noisy - Requires space to produce large amounts of power - Dependent on weather/not feasible in all locations - Hazard to migrating birds
Hydroelectric	- Clean/no air pollution/no waste - Renewable	- Potential damage to riparian habitat - Expensive to build - Depends on location-requires appropriate topography
Tidal (and wave)	- Clean/no air pollution - Renewable	- Can damage tidal zones; destroy habitat - Can only be used in some locations
Biomass/Biofuel	- Cleaner than fossil fuels - Can produce zero net carbon dioxide - Can be renewable	- For widespread use, may require a large area to grow crops - Not as dense an energy source as fossil fuels
Geothermal	- Globally renewable - Does not produce carbon dioxide	- Hotspots can cool off (locally nonrenewable over time) - Sulfur from underground can cause steam to be a pollutant - Only available in some areas
Fuel Cell (Hydrogen)	- No air pollution (water vapor only)	- Infrastructure absent - Source of hydrogen has issues - Still being developed for use in all applications
Solar Cell (Photovoltaic)	- Clean/no air pollution/no waste - New varieties have increased efficiency	- Requires large areas to produce power comparable to fossil fuels - Raw materials are in high demand - Cannot be used efficiently in all places

Positive aspects of fossil fuels are that they are a very high-density fuel. Essentially, with a fossil fuel, you get a lot of “bang for your buck.” Due to the large number of carbon-hydrogen and carbon-carbon bonds, a great deal of energy is stored. Additionally, because the infrastructure for fossil fuels is so well established, deriving electricity from fossil fuels is less expensive than from many other sources. There is still a large supply of resources as well. Although petroleum reserves are dwindling worldwide, coal is still relatively abundant. The estimated United States coal supply is predicted to last for 400 more years at current use levels (Arms, 2000).

Although fossil fuels have benefits, there are also many drawbacks. First, burning fossil fuels is not clean. The particulates emitted from oil- and coal-burning power plants are known to be hazardous and can cause chronic and acute health problems as well as exacerbate existing health conditions. The burning of coal is also a large source of nitrogen oxides, sulfur dioxide and sulfur trioxide gases in the atmosphere due to impurities naturally found in the fossil fuel reserves. These gases, through a series of reactions, are three of the gases which contribute to acid rain, which is a serious international environmental concern, particularly since the source of the rain and the effect of the rain are often separated by tens or hundreds of miles.

Although coal is still fairly abundant, some fossil fuels are in short supply and international conflicts threaten a steady availability of those remaining supplies. Mining new sources of oil, however, is a source of intense conflict due to disagreement between economic and environmental values. (See Appendix A.13 for further discussion.)

In addition to its other problems, robust evidence shows that the enormous amounts of carbon dioxide and other greenhouse gases released through the combustion

of fossil fuels contribute to global warming. This phenomenon may cause changes in global weather patterns, coastland flooding due to rising sea levels, an increase in severe weather and numerous other problems. Ocean salinity changes due to melting ice caps may also change ocean currents and cause some parts of the planet to cool. The global warming issue has recently emerged in both political and popular venues (Appendix A.14).

Like fossil fuels, nuclear power also has pros and cons. A pro of nuclear energy is that fission produces no air pollution. The only expellant to the atmosphere is water vapor from the cooling towers. Nuclear energy is also a powerful fuel source—splitting the plutonium nuclei releases enormous amounts of energy. One gram of plutonium fuel can produce as much electricity as three and a half metric tons of coal (Arms, 2000).

Nuclear fuel is not an unlimited resource, however. The fuel, often from plutonium ore, is also expensive to mine and refine. Furthermore, spent fuel from nuclear power plants is highly hazardous radioactive waste. At present, there is no long-term storage or disposal available for this waste and currently power plants store their own spent fuel rods on site. A proposed national storage site has been proposed at Yucca Mountain, Nevada, but this plan is rife with issues and at best storage will not be available until 2010. It is more likely that concerns with the safety of the location and waste transportation will keep this in debate for several more years.

In addition to waste being a negative feature of nuclear power, cost is another factor. Nuclear plants are very expensive to build and maintain, especially to ensure safety of the plant and its surroundings. Moreover, startup costs increase tremendously

when there is public opposition to a nuclear plant. Cost is one part of the reason no new nuclear plants have been built or planned in the United States for nearly three decades.

There are also safety concerns with nuclear power. The splitting of nuclei releases enormous amounts of heat and requires special mechanisms to prevent nuclear proliferation, or uncontrolled splitting of atoms. Although plants incorporate redundancy and maintain rigorous safety standards, effects of something going wrong can be very costly. Three Mile Island, Pennsylvania, 1979, is an American example of a “mild” nuclear mishap; the meltdown at Chernobyl in 1986 is one of the other extreme. To this day, the core at Chernobyl is still too radioactive to go near without protective gear, and it will remain so for hundreds of years. It will have elevated radioactivity levels for thousands of years. In addition, wind patterns spread nuclear fallout to Belarus and surrounding areas. (<http://www.chernobyl-international.org/facts.html>)

Due to the nonrenewable nature of many of our energy sources as well as the detrimental impact many have on our environment, energy conservation is a choice that should be considered. Conservation can be as simple turning out lights when leaving a room, installing energy conserving light bulbs, and turning down the thermostat. Other ways to conserve include insulating homes, carpooling and purchasing energy efficient appliances.

As with any choice, the choice of whether to conserve energy or not depends on how information intersects with an individual’s personal values. In the context of this course, values are used to explain how people evaluate and make decisions about their world. (Further discussion of values can be found in Appendix A.13.) In the environmental science course, students are asked to personally evaluate their own value

systems and use them along with factual information to justify and understand the decisions they make.

A full understanding of energy does involve recognizing the individual's impact and responsibility in energy issues, matters that must be considered when making decisions as described above. People who use electric lights, for example, should be able to extend some ownership of the consequences of coal burning, since, for example, more than half of electricity in southeast Michigan comes from the burning of coal. Likewise, all consumers of power are responsible for the nuclear waste created by its production. Conservation and reducing use are key actions that demonstrate a mature understanding of our energy use.

It is evident by this summary that energy is a very rich and complex topic of study. By incorporating choice and allowing students to learn through various intelligences and learning styles, as in a layered curriculum, it is hoped that students will develop an interest in and an understanding of energy, as well as be able to see its relevance to their lives.

IMPLEMENTATION

DESIGNING THE LAYERED ENERGY UNIT

The first step in designing the layered energy unit was to identify the content objectives relevant to the MICLIMB standards and benchmarks (Michigan Department of Education, 2002) as well as those specific to the environmental science course. Since in a layered format (the instructional format of this unit) students are allowed to select their own combination of activities with which to meet these objectives, I was concerned that in their selection they might by chance miss out on one or more of the objectives. Therefore, the objectives were divided into three chunks and then color coded to help students stay organized: Objective Set I was copied onto pink paper, Objective Set II onto blue, and Objective Set III onto green. Specific activities discussed in this paper will be referred to by color, letter and number. For the reader's reference, a copy of all objective sets and corresponding activities is included in Appendix B.1.

Objective Set I (the **pink objectives**) addressed energy basics and how electricity is produced from the nine basic energy sources. Specific objectives were:

- *List common forms of energy.*
- *Describe how electricity can be generated using magnets and coiled wire.*
- *Trace the path of energy through the nine common energy sources.*
- *Define and distinguish between renewable and nonrenewable energy resources.*
- *Evaluate energy sources based on cost, availability and environmental impact.*
- *Investigate and be able to intelligently discuss an alternative energy source.*

Objective Set II (the **blue objectives**) related to the consequences of energy use.

Specific objectives were:

- *Consider the pros and cons of common energy sources.*
- *Evaluate long-term consequences of current energy technologies.*

Within the blue objectives, I also subdivided into categories of nuclear, acid rain, global warming, and ecosystems. I required that students complete at least one activity from each subcategory. The remainder of the points could come from any activities. This was likewise done to ensure that students did not miss out on one or more of these subtopics.

Objective Set III (the **green objectives**) addressed individual responsibility and action. Specific objectives were:

- *Evaluate personal energy use.*
- *Describe ways to conserve energy.*
- *Identify and explain reasons to promote energy conservation.*

After the objectives were determined, activities were collected and developed to support each objective. “Activity” in this context refers to any activity students can select and complete to accrue points. This component of planning the unit was a large task, since to reasonably allow choice, many times more than the traditional number of activities had to be offered. Overall, more than 130 activities were gathered or created.

These activities came from textbooks, text ancillaries, the Internet, and various other sources, including some activities used in previous years. Numerous original activities and worksheets were designed and tested during the summer of 2005. Some activities chosen for the unit were traditional reading and “pen and paper” activities such as reading a section of the text and answering the questions at the end. Along with these

types of activities, I also made a conscious effort to identify and include activities that were less traditional in order to meet the goal of providing activity choices that appealed to multiple learning styles and intelligences.

For example, I expected that making a pinwheel (Pink C11) would appeal to tactile-kinesthetic learning styles as well as visual. Pink C4, another activity planned with tactile learners in mind, required that students induce an electrical current in a wire using a magnet.

Another tactile learning activity was Pink C13 in which students make three-dimensional models of the two nuclear processes of fission and fusion. The demos themselves are very simple, with the necessary supplies being clay, marbles and a margarine lid (Appendix C.1). However, they were clear and had the unintended benefit of sound effects, which particularly captured the attention of some students.

I included lectures and Internet audio files which might have been preferred options for auditory learners. Examples of these were the Three Mile Island Interview (Blue C6) and the current research on nuclear fusion radio excerpt (Pink C38). Most of the Internet based audio also had corresponding transcripts.

Many activities were not strictly for one learning style, but certainly extended beyond the traditional school intelligences. For example, Green B5 involved students making two original cartoons relating to one or more of the green objectives. A related cartoon from Foxtrot® was provided as an example. Making a game (Pink B5; Green B6) was another activity that could demonstrate understanding of the objectives but was clearly not a book assignment.

An activity that required out of class action was Green C4, bringing in an energy bill (gas or electric). Although only worth two points, students could earn five points by developing a list of ten test questions using the energy bill. This activity actually allowed me to sneak in a one-on-one lecture to the students. With each student, I could explain how to read the energy bill, what information was provided, and how to understand personal energy use by looking at the bill.

The presentation of weekly current events was an existing component of the class that continued through the energy unit. (Current event guidelines can be seen in Appendix C.2.) Students could incorporate this required component of the class to the unit by selecting an article that was directly related to one or more of the energy objectives.

Creating a song (Pink C30) was an example of an activity aimed at learners with strong musical intelligence. A musical option would also have been accepted as a “Your Choice” (student-designed) activity in any section. Cross-disciplinary activities such as reading Stephen Vincent Benet’s “By the Waters of Babylon” were also offered to appeal to students who were more literary-inclined. Options to utilize interpersonal intelligences were also available, including the “I-LERN” form (Appendix C.3), in which students talk to one another about a lab that one of the two students completed.

Because environmental science is a lab-based course at my school, I wanted to make sure all students completed at least one lab during this unit. Students could select from the labs that were offered or design a lab in any of the objective sets to meet the requirement. Since students would be self-directed, I needed to ensure that the labs I offered could be easily completed and would give consistent, high-quality data. During

my summer work in 2005 I tested a large number of labs for these qualifications. A surprising number of lab activities did not meet these requirements and were rejected. In addition to existing labs that were suitable, several new labs were designed for the unit.

“Heat Bulbs or Light Bulbs?” (Green B1) is an example of an original lab activity in which students compare the heat output of halogen, incandescent and fluorescent light bulbs of equivalent lumen value (Appendix C.4). Students use the data to determine the relative efficiency of the bulbs—the cooler bulb is a more efficient bulb because more electrical energy is converted to light and less energy is converted to heat and wasted.

The equipment for the lab consists of a set ceiling lamp fixtures and lamp cords affixed to plywood bases with large, transparent plastic barrels on top. Plastic fish tank thermometers with suction cups are affixed to the inside of the plastic containers. To do the lab, students put different bulbs in each of the sockets, turn on the lights and measure the temperatures inside each container every thirty seconds or minute. The lab is quite simple but also dramatic, with even the clean up being a learning opportunity—the fluorescent bulbs are cool to touch in just a minute or two, but students have to wait a much longer time before the other bulbs can be handled.

Another original lab is the Pie Plate Turbine Lab (Pink B3). As seen in Figure 2, equipment for the lab consists of a turbine made out of an aluminum pie pan affixed to a shish kebob skewer. The skewer is supported by two clothespins attached to a block of wood. The aluminum turbines are sturdy enough to use a stream of water from the sink as the turning force. This lab is more open-ended than the light bulb lab and allows for a variety of questions to be answered. One possible question is, “Does the force or amount of water have an impact on the turning speed of the turbine?” To answer this question,

students can use different amounts or heights of water. The rate of turning, measured by timing a weighted string as it wraps around the skewer, can be related to the amount of power that can be produced by a hydropower plant. A benefit of the design of this lab is the necessity that students design a procedure that keeps all variables constant.

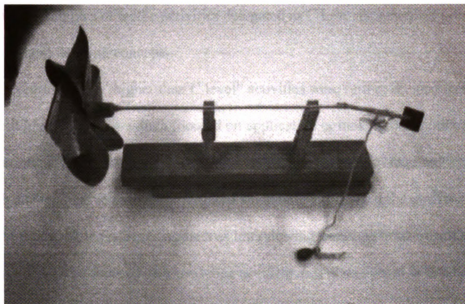


Figure 2: Pie Plate Turbine Apparatus

The next step in the design process was connecting the abundance of activities to the objective sets and assigning them a level. To start this, each activity was listed on a separate Post-It note with different colored Post-Its representing whether the activity was C level (basic knowledge acquisition), higher than C level, or a lab activity. The Post-It notes were placed on large sheets of paper representing each of the objective sets. This helped ensure that there was a fair distribution of activities among each of the objectives as well as enabled easy reassignment of activities if necessary.

In deciding whether activities were C level or higher than C level, I modeled the C, B, and A level activities based on Kathie Nunley's layered curriculum in conjunction

with the levels of Bloom's taxonomy. (See Appendix A.15 for background on Bloom's taxonomy.) Activities that clearly focused on knowledge acquisition were placed in the C level. An example of this is reading a section of the textbook and answering the questions at the end of the section. Constructing a pinwheel and modeling fission and fusion were examples of tactile activities delegated as C level as they dealt primarily with explaining and defining concepts.

Eventually, the "higher than C level" activities were further divided into B and A level activities. Activities which focused on application or making connections among ideas became B level activities. Most activities designated A level required independent research and evaluative thought or required students to act beyond the confines of the school building. Although actions such as interviewing someone from a local solar cell plant may indeed be focused on knowledge acquisition, I placed them in level A because of the social and formal skills needed to complete the activity.

Most lab activities were originally categorized as A level. However, although most lab investigations did require independent thought, their level on Bloom's scale was generally closer to application than evaluation, thus they were moved to the B level. Other activities that were hard to place were either modified or categorized according to what best represented the amount of work required and whether the benefit would extend beyond the classroom.

Once the activities were set, point values were determined for each. For convenience, most activities in the C level were assigned a value of 5 points. B level activities were generally 10 or 15 points each, while A level activities were worth 20 points. At this point, some activities were refined and modified so that they required a

similar amount of effort as their counterparts, making the points and work equitable. In some cases, this meant having more or less a “Part 1” and a “ Part 2” of some activities. Students could choose to complete them in sequence or individually. The pink activities C19 and C24 represent such a pair. At the end of the design process, a grand total of fifty-eight activities had been selected for the pink objectives, forty-three activities for the blue and thirty-three for the green. A traditional unit would likely have a quarter of that many.

The layered curriculum unit designed for this study differed from Kathie Nunley’s in terms of grade assignment. As stated in the course syllabus, one of my overall goals was that students make and defend informed decisions. This included understanding science concepts, as C level mastery should accomplish, but it also required students to internalize and use those concepts. I therefore did not stress to students that C level means C work, and B level means a B grade as I did not want to give the impression that stopping at the C level was a sufficient choice for their learning. Instead, the unit was graded on the points earned over points possible, as is the format for all grades in the class. To manage this, for each level, an acceptable range of points students should earn was provided. Earning the lowest number meant a C or D grade and earning the highest in some cases meant extra credit. Similar to Nunley’s format, students were informed that they should complete the C level of an objective set before moving on to higher levels. However, the points versus letter symbolism of the C, B, and A levels is a significant change from her format.

As in Nunley’s format, however, oral defenses were used to hold students accountable for their learning. In order to promote authentic learning, oral defenses were

required for most C level activities. Those activities which clearly involved independent thought or which were of a nature beyond simple worksheets did not require oral defenses. The *Proposition-Support Outline* (Appendix C.5) is an example of this type of activity. The process of completing this sheet is of its own nature individualized and makes students actively engage with a text.

Most B and A level activities did not require an oral defense unless the work was deemed of questionable quality. Some B and A level activities did require presenting to the class, writing a lab report or some sort of action which was felt to be a reasonable replacement for an oral defense.

I also made a conscious effort to provide students who may be anxious about oral defenses with some choices that did not require defenses to relieve some of the pressure that the one-on-one teacher interview might cause. Also, having non-defense activities could help with time management, as having all students orally defend all assignments could potentially become overwhelming and pose a serious time issue.

Once the background for the unit was fleshed out, all the objectives and activities were organized into three Excel spreadsheets, one for each objective set (Appendix B.1). Columns of the spreadsheet included the objective, the level, the assignment number and a description of the assignment. I also included columns indicating the points that could be earned and whether the activity required an oral defense. The remaining column, titled "Points Earned" was left blank. Students could keep track of their own points earned in the unit in this column. Finally, at the end of each level of each objective set was listed the expected point range for the set. Table 2 below shows an excerpt of the Green spreadsheet.

Table 2: Excerpt of Student Handout for Objective Set III (Green)

Obj	Level	Assmt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher Sig.
III	C	1	Journal Entries: Complete on day assigned and get stamped same day; submit as a group at the end of the week or section. 1 pt each	Variable	NO	
III	C	2	Textbook: Read p. 287 - 294. Answer #1-5. Use complete sentences that indicate the question and the answer. Do not do this if you have already chosen it in a previous objective set.	5	YES	
III	C	3	Video: Green Fingers List 7 things that were suggested to conserve resources. Put a star by one that you think you could do.	5	NO	

IMPLEMENTING WITH THE STUDENTS

Prior to beginning the unit, students completed the energy pre-test (Appendix D.1) and the “True Colors” survey (Appendix D.7). True Colors is a very simple personality survey that is often used with students as an introduction to personality types and learning styles. I used the survey to remind students that each learner is unique and that in the layered unit there would be choices to fit each of them.

Students also completed a multiple intelligences survey (Appendix D.9) midway through the unit on March 13. This survey, modified from a version given to me by a colleague, consisted of a series of descriptions in nine categories. Students put a check next to each statement they thought described them well. The number of checks for each category was tallied and students were able to see their relative strengths in nine different intelligences. It was hoped that this survey would also cause students to be more self-

aware and encourage them to seek and select activities that might be most suitable to their dominant mode of intelligence; when possible, I had labeled activities in each objective set with the predominant intelligence that they utilized.

The unit formally began on February 27, the day after mid-winter break. Students were given the pink set of objectives and the basics of the layered curriculum format were overviewed. Oral defenses were explained and modeled, and the idea of choosing activities was explained. Points of emphasis were 1) student choice of activities did not mean that doing nothing was an acceptable option and 2) time management would be important during the unit.

Students were also given what will be called the “Yellow Sheet” (Appendix B.2). Page one of the yellow sheet had a written description of layered curriculum, the C, B and A levels, and oral defenses. It also had a checklist of the required components for the unit, including the pre and post-tests, the True Colors survey, lab and other requirements.

The next three pages of the yellow sheet were a calendar to help students plan their time and keep track of what they accomplished each day. While much of the calendar was blank, some activity options were already included. These options, such as lectures, teacher demonstrations and videos would only be offered on the date noted. Students did not have to participate in these options, but if chosen, they had to do them on the day they were offered. Additionally, in the first week, some suggested activities were included in the calendar to serve as a starting point for students who did not know how to tackle the task of planning their own activities. Although the yellow sheet had a space for my signature each day, students were told that filling out the yellow sheet was optional as long as they were getting done what needed to be done.

At the end of this introduction, students took the energy pre-unit survey (Appendix D.4). When finished, they selected five activities from the pink sheet that were of interest to them and were told to choose one of those five to begin in class and complete for homework that night.

TIME MANAGEMENT AND PHYSICAL STRUCTURE OF THE UNIT

When students are working on different assignments, management of the room is essential, both in terms of time and in terms of physical arrangement and access to supplies. A crate of hanging files was set up to help with the logistical problems of students working on different assignments. Each activity that required a handout was assigned its own manila folder. The folders were organized by the objective (color), level, and number of the activity. For example, one folder read, “How to Make a Pinwheel C11” with a pink dot next to the name. “HINT SHEET: Heat Bulbs or Light Bulbs Lab B1” with a green dot was another. Several copies of the worksheet, hint sheet, reading, or article required for that activity were in the folder. An original or master of the activity was stapled to the inside cover of the folder. The file box was freely accessible to students.

For labs and activities, boxes were prepared which included all or most of the supplies necessary to complete the activity. The “Make a Pinwheel,” box is pictured in Figure 3. Boxes were readily available to students, and had sheets to explain them in the file folders. (The “Make a Pinwheel” hint sheet can be found in Appendix C.6.)



Figure 3: “Make a Pinwheel” Activity Box

Further organization included limiting lecture time to approximately twenty minutes per day on a lecture day so remaining class time could be devoted to hearing oral defenses and being a presence in the room. Also, gradesheets for each objective set and level were premade to facilitate efficient recording of student points (Appendix B.3).

ORAL DEFENSES

Turning in of a worksheet or assignment was a signal to me that the student was ready to defend. On some days, students were called up individually to defend. Other days open defenses were employed: students could come up voluntarily on a first come, first served basis. When the defense line was long, I made sure everyone had a first attempt before allowing students to defend a second assignment.

Oral defenses consisted of asking the student questions about the work he or she had done. For worksheets and bookwork the questions were often directly from the activity, although clarifying questions were also used. Because I could refer to the student's paper, the defenses could be individualized and focus on areas where the written answers were weak. Unlike Nunley, there was not a set number of randomly-selected questions per oral defense. Instead, my goal with defenses was that the student communicate a full understanding of the entire objective for the activity.

It was possible to earn full or partial points on a defense; however, if a student was unable to provide any quality answers no points were earned. Because I had small classes, students could re-defend an assignment if they did not earn full points on the first attempt. The points for an oral defense were given based on my overall assessment of the student's understanding as well as the number of questions answered correctly or incorrectly. Because the class sizes were small and there was reduced participation in the second half of the unit, the time and management concerns that had been anticipated were not an issue while administering this unit.

OTHER CONSIDERATIONS

As this was my first extended attempt at teaching using a layered curriculum, I expected to make modifications as I went along. One example of this was my assessment of how many points would be needed to achieve mastery in each objective set. Initially, the required number of points for the pink objective set was 90 to 100 points. As we went through the unit, this number was determined to be way too high—based on oral

defense performances, students who had earned 30 or more points seemed to have mastered or were at least proficient at most of the objectives for the set. The point range required for this set was thus lowered to 40 to 50 points. Based on the pink objective results, point ranges for blue and green objective sets were also reevaluated prior to passing them out to students.

Because the layered unit overlapped two grading periods on the school calendar, I set an initial deadline for completion of the Pink C level objectives. Initially, three students in particular were not working at a pace that would allow them to successfully meet this deadline. Completion of the yellow sheet was made a requirement for these students. Each day, the students would have to fill in their plan, and at the end of the day, would have me verify that they completed their plan. These students were also required to give themselves homework. The yellow sheet process was instituted for one week and then students were allowed to attempt to manage time on their own again.

For the remainder of the unit (after the Pink C finish date), I incorporated soft deadlines. For the blue and green objectives there was a combined deadline and students were able to work on blue and green activities in any order. This was in part to allow students to develop their time management and self-efficacy skills and to allow flexibility in the order of doing labs and other activities.

At the end of the unit, March 31, students took a formal unit test (Appendix D.11). The following Monday, April 3, students completed the post-unit survey (Appendix D.5) and the self-evaluation (Appendix D.6). This was also the final day for oral defenses. A unit test retake was administered on April 10, and the post-test (Appendix D.2) was given on April 11.

RESULTS AND DISCUSSION

ANALYSIS OF STUDENT PERFORMANCE ON PRE- AND POST-TEST

Overall, students showed improvement between the pre-test and post-test. The average score out of twenty-four points for the pre-test was 24%. On the post-test the average was a 62%. Average score on each question also increased, as seen in Figure 4. A paired t-test of individual scores for each test item shows the null hypothesis clearly unsupported ($p=0.001$) in all but two of the questions (Table 3). Additionally, the number of answers students left blank and the number of answers earning zero points were both reduced between the pre- and post-test (Tables 5 and 6).

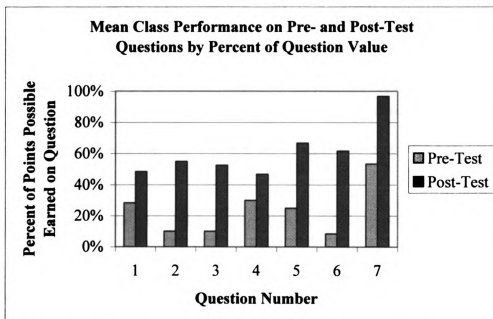


Figure 4: Mean Class Performance on Pre- and Post-Test Questions by Percent of Question Value (n = 15)

Table 3: Paired T-Test Comparing Pre- and Post-Test Data

Item	t =	Degrees of freedom	The probability of this result, assuming the null hypothesis, is
Question 1	-2.20	13	0.047
Question 2	-5.16	13	0.000
Question 3	-6.09	13	0.000
Question 4	-1.10	13	0.293
Question 5	-4.56	13	0.001
Question 6	-4.60	13	0.000
Question 7	-6.62	13	0.000
Total Score	-9.72	13	0.000
Answers left blank	3.63	13	0.003
<i>Numbers calculated using http://www.physics.csbsju.edu/cgi-bin/stats/Paired_t-test</i>			

Although overall scores improved, the layered curriculum did not expand students' understanding in every area addressed by the pre-test. Of most concern was Question 1. Students were asked to "List the forms that energy can be found in in the universe." Students across the board listed energy *sources* on the post-test, such as hydroelectric, fossil fuels and wind, instead of energy *forms* such as kinetic, potential and thermal. One student who had correct answers on the pre-test responded with incorrect answers on the post-test.

One reason for the poor results on Question 1 might be poor reading or test-taking ability. I have noticed that students in my classes often do not read well, or do not recognize the subtle differences in meaning between similar words. Sometimes there is *accompanying* apathy in situations regarding language nuance.

An equally likely reason for the poor answer quality may be that students did not *know* the information and were not exposed to it in the unit. Forms of energy was the

first objective for the pink set of objectives and was embedded in several activities.

However it was really emphasized only in Pink Activity C23 (Appendix C.7) which was defended by only four students. Students who did not select this activity may not have had the learning experience necessary to understand and answer the question. Two of the three students who earned full credit on Question 1 did in fact select option C23.

Question 2, “Trace the path of energy from coal to your light switch,” showed statistically significant improvement in understanding of the content. Students were permitted to use diagrams and labels to explain the process. To earn all four points possible for this question, students had to list or label all of the following steps: coal is burned, the heat is used to turn water into steam, the steam is used to turn a turbine and the turbine turns a generator to produce an electric current. Some students who earned partial credit on this question knew that the coal was burned, but they indicated that the burning of coal directly created steam. Still, the difference between the pre- and post-test was obvious, with the average score (out of four points) being 0.5 on the pre-test and 2.8 on the post-test. In pre-test answers, the maximum earned score was only two points and was earned by only one student. Several students left the answer blank. Of those who responded on the pre-test, a few indicated that coal was burned. However, most explained the process of generating electricity using a “black box” idea: students drew a building labeled “DTE” or “Factory.” Coal went into the building and electricity came out. Unlike the content of question 1, this topic was covered in numerous activities including in lecture, reading, and textbook form. This redundancy possibly contributed to the student success and improvement on this question.

Responses to Question 3 also showed significant improvement. To earn all four points possible, students had to list common energy sources and correctly describe at least one pro and con for each in data table form. Students were able to earn partial credit on this question; deductions were taken for incorrect information. The number of students earning points on this question (as opposed to scoring zero points) increased dramatically from only three students on the pretest to all but one on the post-test. A few students did have at least one error or blank in their table. For example, one student stated that solar power causes cancer, perhaps confusing the use of solar power with the sun's emission of ultraviolet light. Many students listed only three energy sources instead of four, but had a majority of the pros and cons correct. One student had a perfect score for this question. If the phrasing of the question had been more specific in the number of sources expected, the actual percentages earned may have been higher.

In answers to Question 4, "Who is responsible for nuclear waste?" several students showed a very limited or entirely absent understanding of what nuclear waste is, even after completion of the unit. This was evident in such post-test responses as:

"I am responsible for nuclear waste...because of all the stuff I produce, like trash and body waste."

"We are because of the amount of garbage we throw away each year."

"The entire human population is responsible for nuclear waste because we're always dumping trash instead of recycling."

"Yes, I am responsible for nuclear waste. This is because the amount of pollution I have placed in the atmosphere not directly but maybe by driving."

In addition to having no understanding of the definition of nuclear waste, most students who did not answer correctly had vague answers that showed no conscious connection between nuclear waste and energy consumption (Appendix D.3).

The content for Question 4 was covered in the blue and green sets of objectives and several activities were available that addressed this objective: Blue activities C2 through C7 emphasized nuclear waste, green activities C4 and C6 emphasized personal responsibility and what sources are used to produce the electricity for Southfield. Unfortunately, from all the students in the study combined, only a total of only five activities were defended for the nuclear waste subsection of the blue objectives. The lack of understanding on Question 4 may be therefore attributable to the lack of participation by students more than a deficiency in the activities or activity choices.

Although overall disappointing, one positive aspect of the data for Question 4 is that on the post-test four of the students earned full credit because they were able to communicate and justify a high level response, indicating that anyone who uses electricity that is derived from nuclear power is in part responsible for the waste it produces. On the pre-test there were no students who earned full points on the question.

Question 5 covered the renewable and nonrenewable resource benchmark. This benchmark is also addressed in the first semester Environmental Science course (Conservation) that many students took. Although on the post-test, some students still confuse reusable with renewable, many students were able to provide examples of renewable and nonrenewable energy sources, earning partial credit on the question. Two of the video selections which were offered dealt directly with comparing and contrasting

renewable and nonrenewable energy sources. Most students in the study had selected these videos to fulfill part of their Pink C requirement.

The confusion between renewable and reusable is one that students demonstrate over and over again despite the fact that when the concept is introduced in this course, the misconception is immediately addressed, and definitions are restated each time the terms are subsequently used. As students are far better at citing examples of these terms than actually defining them, it may be that misconception stems from an issue of language nuance, as might the distinction between energy form and energy source.

For the open-ended Question 6 students had to select the form of energy that they thought had the least negative impact on the environment and use correct information to justify their selection. Because I was not as specific as I often am in the question phrasing, and because the amount of space provided on the paper was small (which may have been a nonverbal signal to students about my expectations) students were allowed to support their answers using only one reason and still earn full credit.

Most students selected a renewable energy source to answer this question. Eight students selected solar energy, four selected wind, and one selected geothermal (a poorer answer). These results are satisfactory in that they suggest that students have some understanding of the negative impacts of many of our nonrenewable sources. Common supporting evidence included cost, pollution, habitat destruction and renewability. In order to earn full credit, the reasons had to be factually correct and appropriately support the statement. Sample answers to this question are shown in Table 4.

Table 4: Student answers to Question 6

Question 6: What form of energy/electricity has the least negative impact on the environment and why? Use reasons.
<i>Examples of answers earning two points:</i>
“Wind power because the wind mill does not pollute the air nor give off any gas. The only negative thing about it would be the fact it kills or can damage birds and other air habitat creatures.” “Solar energy because the only impact would be economically. It is a source that is renewable and we can use time after time.” “Wind power has the least negative impact on the environment because it doesn’t give off dangerous chemicals or kill people if it explodes. And it is renewable and it can’t be overused.” “Solar has the least negative impact on the environment because it causes no pollution” “Sun has the least negative impact on the environment. It is apart [sic] of the environment and is in abundance and it’s a renewable resource.”
<i>Examples of answers earning one point:</i>
“The form of energy that has the least negative impact on the environment would be solar, because not only is it cost efficient, but it is a good way to conserve energy.” “Solar energy has the least negative impact on the environment because solar panels are used on the roof and it does not harm other species.”

Some reasons the second group of answers did not earn full points are that their factual information was incorrect or debatable, or their reasons did not support their argument. For example, depending on the location, solar energy is not necessarily cost efficient. Also, stating that solar energy is “a good way to conserve energy” is signal that the writer does not have an understanding of either solar energy or conservation. That

solar panels are used on the roof is irrelevant to the argument that solar energy has the least negative impact on the environment.

Like Question 5, prior knowledge was also evident on Question 7: on the pre-test, only one student left this question blank and all but two students earned two points or higher out of four points when asked to list ways to conserve energy. Nonetheless, students still were able to provide more answers on the post-test, with one student listing nine different methods of energy conservation. The phrasing of this question (“list as many as you can”) may account for some students not earning all four points. Four was chosen as a number that represented a high quality answer, but many students answered three correct responses. Had a specific number of responses been requested, there may have been an even higher percentage of students earning full credit on this question.

The number of responses earning no points was reduced from 40% on the pre-test to just 8% on the post-test (Table 5). In particular, questions two, three, five and six show noticeable improvement. The number of blank (unanswered) responses decreased, from 14% to 8% (Table 6). Blank answers can be an indicator of lack of knowledge or lack of confidence. The smaller number of unanswered questions on the post-test could therefore be interpreted as a positive indicator of learning or of improved self-efficacy.

Table 5: Number of Responses Earning Zero Points on Pre-Test and Post-Test
(*n* = 15) (*n* = 16)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Pre-Test	5	6	9	5	6	10	1
Post-Test	3	0	1	3	1	1	0
<i>Difference</i>	<i>2</i>	<i>6</i>	<i>8</i>	<i>2</i>	<i>5</i>	<i>9</i>	<i>1</i>

Table 6: Number of Responses Left Blank on Pre-Test and Post-Test
(n = 15) (n = 16)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Pre-Test	2	4	2	2	1	3	1
Post-Test	0	3	2	1	1	2	0
<i>Difference</i>	<i>2</i>	<i>1</i>	<i>0</i>	<i>1</i>	<i>0</i>	<i>1</i>	<i>1</i>

ANALYSIS OF PRE- AND POST-UNIT SURVEY RESPONSES

The data from the pre- and post-unit surveys (Appendix D.4; Appendix D.5) correspond with the differences in pre-and post-test data. On the post-unit survey, forty-seven percent of students (seven out of fifteen) agreed or strongly agreed with the statement, “I feel more confident about what I know about energy than I did at the beginning of the unit.” Only thirteen percent of students (two out of fifteen) disagreed or strongly disagreed with that statement.

Based on the post-unit survey responses to Statements 21 through 23, the class as a whole did not like layered curriculum, prefer it to traditional instruction or feel that it helped them learn more. Half or more of students disagreed or strongly disagreed with each statement (21: 50%, 22: 57%, 23: 57%) while fewer agreed or strongly agreed with them (21: 29%, 22: 29%, 23: 36%). It is of interest to note: four students strongly disagreed with all three statements, while four students strongly agreed with all three.

While the proclaimed enjoyment of the unit was limited, students did express that they knew more about energy at the end of the unit than at the beginning. Sixty-seven

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percent of students indicated agreement and only twenty percent disagreed with Statement 24 on the post-unit survey (“I feel like I know more about energy than I did at the beginning of the unit”). Likewise, on Statement 6 (“I know a lot about energy”), there were overall changes toward agreement, with all but four students moving their answers to the right. The four students who did not express stronger agreement had no change in response. Table 7 below summarizes the class trend, with notable movement along the gradient in a positive direction.

Table 7: Class Survey Responses to Statement 6 “I know a lot about energy”

<i>Statement 6: “I know a lot about energy”</i>	Disagree or Strongly Disagree	Neutral	Agree or Strongly Agree
Pre-Unit Survey	79%	14%	7%
Post-Unit Survey	14%	71%	14%

Another positive outcome revealed by the post-unit survey was that students felt strongly that, “The study of energy relates to my life.” On the pre-unit survey, half of students disagreed or strongly disagreed that the study of energy relates to their lives. Only thirty four percent agreed or strongly agreed. On the same prompt after the unit, only fourteen percent disagreed with the statement while seventy-one percent of students felt that the study of energy was relevant to their lives.

Students also showed change in their perception that “Learning about energy can be interesting.” Half of students agreed in the post unit survey whereas only slightly more than a fourth had agreed beforehand. Table 8 below summarizes the responses to the relevance and interest prompts.

Table 8: Likert Scale Responses to Relevance and Interest Survey Questions

	Pre-Unit		Post-Unit	
	Disagree or strongly disagree	Agree or strongly agree	Disagree or strongly disagree	Agree or strongly agree
“The study of energy relates to my life”	7	5	2	10
“Learning about energy can be interesting”	4	4	2	7
Data are included only from students who participated in both the pre-unit and post-unit surveys; n = 14				

Self-awareness of energy use and willingness to act on information did show change. More students agreed with the Statement 10 (“I use a lot more energy than I really need”) at the end of the unit than at the beginning. Agreement increased from seventy-one percent to ninety-three percent, with all but one of the students indicating agreement. (No student gave a neutral response to this on the post-unit survey although one student disagreed with the statement.) Students also seemed willing to take action in regards to energy consumption. At the outset, nine students responded neutrally to Statement 11 (“I would be willing to make changes to conserve energy”) while only three agreed. After completion of the unit, six were neutral and seven agreed. Fifty percent of students expressed willingness to change whereas the pre-unit number was twenty-one percent. (Analyzing data individually, two students had less agreement than their original response suggested, but all others remained the same or moved toward more agreement.)

Students seemed to have less positive views of their ability to set goals and complete them on time at the end of the unit, as shown by their responses to survey

Statement 4. (Pre-test: 21% disagreed while 42% agreed; Post-test, 42% disagreed while only 29% agreed.) Although these results could indicate a decrease in self-efficacy, the results from Question 5 (“I can do well in a science class”) show that efficacy in science for the class as a whole did not change across the midline. Individual data show that most students did not change much: Eight out of fourteen students did not change their responses at all between the pre- and post-unit survey, three students decreased their numerical response by one step on the Likert scale, two students moved up the scale by one step, and one student increased agreement by two steps. More research would have to be done to investigate the effects of this unit on student views of self-efficacy.

Although many students could not articulate their relationship to nuclear waste on the post-test, the survey responses showed a dramatic increase in ownership of the nuclear waste issue, implying at least an affective change in this content area. Initially responding to the statement, “I am [partly] responsible for nuclear waste,” thirty-seven percent of students disagreed or strongly disagreed with the statement. On the post-test the combined disagree percent had dropped to seven percent. While the number of responses which were neutral remained the same between the pre and post-test, the number of students who agreed or strongly agreed on the pre-unit survey increased from thirty-five percent to sixty-four percent on the post-test.

On the free-response portion of the post-unit survey, students wrote these answers identifying the best thing about layered curriculum:

“that we got to set our own dates to turn in assignments”

“that I picked what assignments I wanted to do”

“you choose what you’re going to do each day”

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“that you had your own pace and not that rushed into a deadline”

“the ability to choose what you want to learn and how you want to learn it.”

“the different assignments you had a choice in what you wanted to do”

“the variety of different assignments”

“not having to listen to an instructor everyday”

“I didn’t have to listen to the teacher.”

Nearly all these responses imply that choice and variety were a central facet of the enjoyment of the unit. However, students were ambivalent about choice. One student who stated that the best thing about layered curriculum was “I have a choice of what I wanted to do” answered that the worst thing about layered curriculum was, “I had a choice of what I wanted to do which made me very indecisive.” The student who cited not having to listen to an instructor stated that the worst thing about layered curriculum was “being overwhelmed with choices of assignments”

The Likert portion of the survey showed a change in attitude by the class as a whole regarding the role of choice in learning (Table 9). Students overall were less emphatic at the conclusion of the study than they had been at the beginning on both Statement 2 and Statement 3. On an individual basis, seven students kept their original answers from the Likert scale, three students moved their answers one space to the right, four students moved one space to the left and one moved two spaces to the left. Statement 3 results were similar.

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Table 9: Student Likert Responses to Choice in Learning

	Number and percent of students answering 1, 2, 3, 4, and 5 on Likert Scale (1 = strongly disagree ←→ strongly agree = 5)									
	Pre-Unit Survey					Post-Unit Survey				
	1	2	3	4	5	1	2	3	4	5
Statement 2: <i>Students should be able to choose how they learn</i>	1 7%	1 7%	3 21%	2 14%	7 50%	0 0%	2 14%	5 36%	3 21%	4 29%
Statement 3: <i>It is easier to learn when you are given a lot of choices.</i>	1 7%	2 14%	3 21%	2 14%	6 43%	1 7%	2 14%	4 29%	3 21%	4 29%

(n = 14)

Explanations for this change could include that students attributed frustration in the unit to the amount of choice, students were overwhelmed by the challenges of being self directed, or that students perceived that having choice is more work than being told what to do. Further study is needed to make a valid assessment of the cause.

Some students seemed aware of their own involvement and expectations in the unit. One student who did not like the layered curriculum wrote, “I felt like I had a lot of free time but I really did not.” Another student wrote, “There where [sic] some assignments that I had reall [sic] truble [sic] with and they were computer assignments so I had to do them at home.” This student stated that she learned the most from lecture.

Asking about oral defenses elicited a variety of responses. Two students cited the best thing about layered curriculum were activities that did not involve oral defenses. One of these even described the defenses as “devastating,” although he did complete all required points for the C level of the first objective set.

Other students stated that, “Oral defenses were...”:

“different. I don’t like them at all though, yes it did prove that you know your work, but if your [sic] not good at oral things that is bad news.”

“kind of hard but at times easy depending on what you know”

“OK, but nerve reckoning [sic]”

“pretty easy. They made me feel like I was smarter because I knew the answers.”

“starting to get on my nerves”

“hard at first but you learned a lot afterward”

“Pointless because I wouldn’t remember most of the information anyway”

“one of the main reasons people didn’t turn in work like they should”

“good because that way I could remember what I did longer”

“easy if you read”

“neat and it made me actually read what I do”

Two students responded that oral defenses were “neutral” and “okay.”

Three themes rose up from students’ answers regarding the worst thing about layered curriculum. They were

1. oral defenses
2. time limits being too short
3. not having direction from teacher/being overwhelmed with choices

Several students named learning about their own energy use and how to conserve energy as their favorite part of the unit. Another frequently listed answer was learning about other kinds of energy. Two students named labs as their favorite part of the unit

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while one student listed videos. One student listed his favorite part of the unit “the pink packet because I got all my points.”

In an illustration of the individuality of learners, there was almost no duplication in responses to the prompt, “I learned the most in this unit from...” Students wrote that they learned the most from:

- Labs and creative assignments
- Writing essays and researching
- “The blue packet”
- Lecture
- Textbook and videos
- The “ODs” [oral defenses]
- News articles
- “The time that I used the work to compare to my life”
- Worksheets and the lab
- Worksheets and videos
- Discussing and working as a class

ADDITIONAL COMMENTS

Although these data show improvement in comprehension of particular energy content objectives and other positive changes, the overall performance of the students after the first week or two of the unit was disappointing and indicative of lack of motivation. After the pink C level, a majority of students simply stopped completing and

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defending assignments: Of the students in the study sample, more than half earned no B level nor A level points. Only one student earned any A level points in any objective. Four students earned zero points in the blue set of objectives and three students earned zero points in the green set of objectives. Two students each earned a total of only fifteen points overall out of the required minimum of 265 points, even with teacher support.

Students were given the opportunity to assess themselves in the context of the unit on through a set of self-evaluation questions (Appendix D.6). Self-ranked motivation ranged from two to ten on a ten-point scale with the average being 6.8. Self-ranked effort ranged from 40% to 100% with the average being 74%. Students' declared motivation and effort did not always correspond with their grade. One student who claimed motivation as a five out of ten and responded that she gave about forty percent of her best effort stated that she felt her honest grade in the unit should be a C-. This lack of causality and seemingly external locus of control was also reflected in the one-on-one interviews I had with students at the end of the unit.

A few students did show some cognizance of their actions or inaction affecting their grade. Many students justified giving themselves a higher grade, however, by saying they did the work but just didn't defend it. Some students were honest in their self-evaluations:

"Had I the MO [(modus operandi?)] to work period I would have done better now than before."

"After I realized that I was not understanding and unable to keep up I just kind of gave up."

One student who noticed that the level of achievement in the class had decreased proposed a reason why in his comments on the post-unit survey.

“I like [layered curriculum] because it makes you have to teach yourself but in a way that same reasoning can also or was many of our down fall, especially in the blue and green packets because after a while you start to get lazy.”

Another student suggested that oral defenses were the reason students did not do work.

Overall, a disappointing number of students rejected their own accountability in the unit in favor of identifying an external cause of failure.

CONCLUSION

My excursion into designing a new energy unit was driven by my desire to increase student engagement and learning and to provide more ways to meet the needs of the diversity of my learners' intelligences and learning styles. In terms of the content objectives, the pre- and post-test data suggest that students did increase in their understanding of most of the objectives (Table 3). Additionally, students professed an increased likelihood to act on their knowledge as shown by responses to Statement 11 on the post-unit survey, "I would be willing to make changes to conserve energy." Half the students in the subject group agreed with this statement. This can be interpreted as authentic learning because it involves action within a real context. It also speaks to learner retention as retention is more likely when students internalize and use what they have learned. Further, students choosing to apply energy unit information to their lives clearly indicates perceived relevance as well as motivation.

The unit also met the objectives of providing more hands-on activities and incorporating more opportunities to learn through multiple intelligences. Several new labs and activities were designed with this intent in mind and existing classroom activities were selected for their ability to convey relevance and appeal to different types of learners. Some of these activities were very successful at engaging students.

The "Bring in your Energy Bill" activity (Green C4) was one such activity. Some students came in with their bills having no idea how to read or interpret any aspects of them. In essence, this provided a "teachable moment" for each individual who brought in a bill. With each student, I went over how to read the bill, how to estimate future bills

based on use history, and had the student suggest reasons why some month's charges were greater than others and ways to reduce the total bill. Because the bills were real and relevant, students seemed authentically motivated to find out about their bills and their own energy use. The end result of this activity choice was that it was both enjoyable for me as a teacher and relevant and informative for my students as learners.

I was most surprised by the success of the baby food jar galvanometer activity ("Create an Electric Current" Pink C14). During one of the teacher demos (Pink C6), I had made an electrical current using the same supplies as were provided to the students for this activity (baby food jars, magnets, assorted wire and ammeters). I showed how the number of coils, the size of the magnet, and the intensity and direction of the motion of the magnet relative to the coils all influenced how much current could be created. To earn points for C14, all students had to do was induce a current perceptible to the meter.

Students tried creative arrangements, some incorporating combinations of magnets and multiple baby food jars. I had expected students to easily induce a current, but this was not the case. In fact, several students worked on this assignment for two class periods and showed surprising persistence to achieve the goal. As Fetsco (2005) suggests, persistence is an indication of motivation, thus it can be followed that there was strong motivation to achieve the goal. Indeed, these students were so excited when they finally saw the ammeter needle move that I couldn't help but feel their sense of pride!

I believe the labs and tactile activities really did affect learning for the simple fact that they were most engaging. Surprisingly though, the "Heat Bulbs or Light Bulbs" lab (Green B1), which I thought would be the biggest hit, was not. This may have been influenced by the fact that some students had waited too long to do the lab and were

rushed. Some students may not have wanted to do the minor set up that the lab involved. It may even involve the fact that the lab took up a lot of room and made students feel conspicuous in the classroom—a private student might not like the possibility of being a focal point in the room. Students who did conduct the lab did say they enjoyed it.

The Solar Cell Lab (Pink B1) was selected by many students. Some students did the lab on one day, and word of mouth seemed to spur several other students to complete the lab on the next day. This lab was more open ended than the Heat Bulb or Light Bulb Lab and allowed for more variety in the question that was answered. I was genuinely impressed at the design skills (selecting a question), problem-solving skills (the movement of the sun had to be accounted for during the lab), analytical skills (tools had to be selected and used correctly to ensure same conditions for each trial) and patience that some students showed while completing this lab.

The insulation lab (Green B2) was successful as an engaging tactile activity; the three students who did this lab were meticulous in fabricating their insulated containers. It seemed that students needed more guidance in meeting the content objectives of the lab, however. More background reading may have helped with this, although a tactile student will usually jump right in to a lab without reading background or supporting materials. Emphasizing the post-lab graphs or requiring oral defenses before the lab write-up might be practical places to start to make sure students grasp the objectives.

Two students worked with the pie plate turbines, although only one wrote a lab report. This lab gave students an opportunity not only to develop and answer a question, but to determine how to use the equipment in answering that question. The report turned

in was not of the best quality, but given the student's background, was an acceptable first attempt. I did request a rewrite of some sections; unfortunately I did not get the rewrite.

Incorporating current events was also a nice aspect of the unit. This worked out very well for the four students who got to "double-dip" for points, as no extra work was required to earn the layered points. Since current events are presented to the entire class, this part of the unit also helped students who did not choose the activity by providing examples of relevance.

Although some of my goals were clearly met, whether or not student motivation increased is more difficult to assess. I do think that initially, motivation was improved from previous years.

Bigge (1971) indicates that relevance and interest can increase motivation. As seen in Table 8 in the Results section, after the unit a majority of students felt that the study of energy was related to their lives. Students also indicated that the study of energy could be interesting. These data imply that students had some motivation during the unit. Student engagement and positive attitude also imply motivation, and several activities encouraged these conditions.

The literature also indicates that choice is a powerful contributor to motivation. By de facto, the entire format of the unit should have caused increased student motivation. Nearly all responses on the post-unit survey regarded choice as a positive aspect of the unit. Additionally, some students were observed to be very deliberate in their selection of activities so as to meet personal goals. Affective enjoyment encourages motivation, and deliberate choice signifies that it exists. Thus, circumstantially, it follows that motivation was enhanced by the student choice involved in the unit.

Although conditions supported motivation and evidence supports that students were motivated at times, other evidence indicates that motivation was not sustained for the duration of the unit. The lack of participation, one of the most disappointing aspects of this unit, was a direct product of poor motivation. While most students completed or had come close to completing the requirements for the Pink C Level, subsequent levels and objective sets were not even attempted. Even though the opportunities for choice and engagement still existed, students were not motivated to finish the remainder of the unit.

Another indication that students were not fully motivated was their failure to take advantage of second chances. For example, I chose to give a retake on the formal energy test because I did not accept the poor results I saw in the exams. I told students that they would retake this same test in a week, and at any point before then, they could come see me at lunch or after school to go over their answers. This was to allow students to improve their grade and also to give me the opportunity to reteach on an individual basis, but essentially, students were being allowed to practice with the same test they would be retaking. As evidence that motivation was lacking, only two students came back for help even given the generous conditions.

Some of my most unmotivated students in the layered curriculum were also unmotivated in other units of the semester and showed the same level of apathy. For example, two of students who were required to complete the yellow sheets showed no improvement in performance, even after parent contact. Although theoretically the layered format should encourage motivation, as Fetsco (2005) states, “It is impossible to predict precisely how an instructional activity will affect individual students.” Some burden rests on the student alone.

PREEXISTING CONDITIONS

Some reasons for the unsuccessful aspects of the unit are likely similar to those experienced by all high school teachers. Students come to classrooms with varying levels of intrinsic motivation, external loci of control, and predispositions to learned helplessness. Based on student behaviors and conversations and on past performance in science classes (some students were in the position of needing the half credit from this course in order to meet graduation requirements due to past failure), it is likely that some of my students have learned helplessness and/or an external locus of control, both of which can negatively affect motivation and endurance.

The intrinsic motivation and the intentions of students are also complex factors that have their start well before a student enters class. As an example, during the middle of this semester, I heard two students say that they didn't care about doing well because they didn't need this class to graduate. One of these students said this loud enough to ensure that I heard. This particular student seemed in fact to actually have more motivation to fail than to pass. More than once she said comments that portrayed the attitude of, "I'll show you—I'll fail, and I'll still graduate." Obviously the issues behind such motivation are very complex.

Also presenting a challenge is the predominant student culture in my school which tends to encourage denial of ownership and transference of blame. I tried to alleviate this kind of peer pressure by having individual conferences with students to discuss their grades. However, it seemed as if this condition of denial was very deeply ingrained. General absence of accountability and ownership was particularly noticeable

in conversations with students in which they showed no acknowledgement of the connection between their work and their grade. Students justified their nonwork behavior by the fact other students also were not working. A few students were honest in the one-on-one conversations, but many reverted back to transference when the class was perceived to be involved. The lack of ownership students had over their performance was very frustrating to me as the instructor.

One last less tangible thing that impacted the learning was the development of “senioritis” by some of my students. Although the unit was administered in March, seniors in my class were already counting down days until graduation and exhibiting less effort on assignments.

THINGS WHICH COULD BE CHANGED

Many students claimed that they were not given enough time to do the blue and green objectives and this may indeed be true. However, the result should have been simply lower scores in these areas, and not the absence of a score as was often the case. Nonetheless, in analyzing the successes and failures of the unit, including the diminishing work, some factors were noted which could be changed to improve success on a future attempt at this format.

Deadlines were one such factor. As stated earlier, due to the end of the school marking period, a firm deadline for the C level of the pink objectives was established. While some students were working at a reasonable pace at the beginning of the unit and others were slow to complete and defend assignments, as we approached the deadline,

many students made a much more concerted effort. Three students even came after school to defend assignments. Of the students in the study at this time, seven out of fifteen met the goal of 25 points. An additional five earned between 20 and 24 points. The remaining three students earned 16, 13 and 8 points, respectively. The average points earned per student was 22.5 points. Having a short-term, set deadline seemed to positively influence student work.

When I passed out the blue and green objectives to students and gave a combined deadline, I think students perceived this as an overwhelming task, especially since some students still needed to complete their pink B and A level activities. While I wanted students to develop their planning and time management skills, I think I gave too much to handle at once and students were not ready for that level of autonomy. Some students responded by shutting down; it would seem that certainty of failure was more attractive to these students than the uncertainty of how to approach and break down the task. The ambiguity of where to start on such a large task may also have increased anxiety in some students. Procrastination, or failure to start [the blue and green packets] may have been employed by some students in order to avoid this stress (Fetsco, 2005). Unlike the firm Pink C deadline, which motivated students to action, the seemingly abstract deadlines for the other objective sets motivated students to inaction.

Deadlines could be restructured to prevent some of the debilitating stress that they caused. What might have better results would be to give out the unit in smaller pieces, or at least only one objective set at a time. Also, weekly checkpoints could be incorporated into the unit, similar to the hard deadline set for the pink C objectives. At each checkpoint, students would be required to total their points from their sheets. Those

students not meeting the posted goals would need to use the yellow sheet until the next checkpoint. Doing this even weekly would allow students more tangible feedback than merely assuming students will set deadlines on their own. Such guidance would help my students who are driven by a motive to avoid failure. Considering this was the first time through a layered curriculum for many of my students, and that many of them are not used to having choice, I feel that instituting short-term deadlines would be an improvement to the unit.

Another way to improve would be arranging for either more lab time or more direction. Because of the desire for labs to be student-driven, “the answer” to the lab was not given in the information provided to students. Unfortunately, several students absolutely missed the point on some of the labs—one student confidently explained that the hot light bulb was the better choice for conservation because it was giving off more energy. Clearly this student had misconceptions or absence of knowledge on the basic definition of efficient, and on the relationship of watts and energy. I found that even after discussing these concepts with her she maintained her misconceptions in her lab report. Either lab format, pre-lab information or post-lab discussion need to be addressed.

The issue of some students not being able to relate the forms of energy might be addressed by some modification of the pink objective activity choices. Since there was only one worksheet which overtly addressed this content area, adding more activities, making C23 a required activity or making alterations to other activities might help to alleviate this problem. Again, this is something I can modify.

Many students used, “But I did it, doesn’t that count?” as a justification for not doing oral defenses, even though the expectations of the unit and the value of oral

defenses were clearly expressed to students at the beginning of the unit. Some students failed to see or admit the direct connection between failing to defend activities and failing the unit. It may or may not be possible to influence the attitude of students. However, in a future attempt at layered curriculum, some aspects of oral defenses could be changed, to make them seem less like a teacher-imposed facet of the unit and more like an opportunity to express learning. For example, students could be allowed more choice in defenses, such as determining the time, place, number of questions or other aspects of the defense. Changes could also be made to reduce the likelihood that students get so far behind in their defenses that they feel like giving up. This could also address anxiety, as fear of the unknown might diminish as students get more comfortable with each subsequent defense.

THINGS THAT WORKED WELL

Although oral defenses overall were not the most successful aspects of the unit, one of the very positive aspects of the unit to me was when individual defenses were successful. A few times I really experienced the best aspects of this form of assessment. For example, I had one student come up early in the unit with a textbook activity. Every written answer on the page was incorrect or incomplete. However, as I probed with additional questions, I could almost see the light bulb go on. After a few stumbling answers, the student began to correctly explain each of the questions on the paper. This student who had turned in a paper that would have earned zero points in a traditional format was in the end able to talk me through the ideas she needed to earn full credit.

(Incidentally, this student had a tie score in five different intelligences but was very strongly “blue” in the True Colors Survey.)

A few of the comments on the survey indicated that some students also saw benefits of oral defenses. In addition to responses already listed in the Results section, one student communicated that doing oral defenses allowed him to learn what he didn’t know. Another commented that oral defenses were “good because I could remember what I did longer.”

Something else that worked out well in some cases, albeit not in the way I had anticipated, was student choice. Specifically, one student sought out and completed every activity that did not require an oral defense. While I was somewhat discouraged that this student was not getting the benefits of the oral interviews, the student certainly showed motivation as well as conscious choice in picking activities that he wanted to do. He was in actuality meeting some of my goals for the unit and certainly felt more control in the classroom than he may have in a traditional unit.

The research indicates that teaching specifically to a student’s learning style is not always effective but that varying instruction and offering multiple activities may effectively meet the goals of addressing learning styles and intelligences. Anecdotal evidence from my unit supports this: Although two students scored musical intelligence in their top two on the multiple intelligences survey, surprisingly, no one elected the option of creating a song.

One of my students was always reading for pleasure. I included the Benet short story thinking it would appeal to her. She did begin the story, but did not follow through with it (another example of student selections surprising me). However, other activities

caught her interest. She named labs and creative assignments as what she learned most from in the unit. An example of one of her assignments is below. This is what she submitted for Blue C4, writing a poem dealing with nuclear waste issues.

Goodbye to the trees I used to know
Goodbye to Mr. Chow
Goodbye to candy shops and ice cream stores
Goodbye to soft pillow shop with the hardwood floor
For you are all gone from a 10 day fire
No more signs in windows say looking to hire
April 26, 1986 was a day of pain
There is nothing left to gain
When ton of toxic waste was flung into the air
And land on my new bobcut hair
Which was carried by a soft breeze into Belarus
It's all because of a little fuse.

While this is not full of facts, it does show an understanding of the emotional response to a potential negative consequence of using nuclear energy. Therefore it met the stated requirements for this selection. It also allowed this student to meet an objective in a way that suited her learning style and intelligence, which was one of the goals of the unit. To complete the points, this student opted to read her poem to the whole class.

The teaching objective of individualizing instruction did work, as indicated by the range of student choices. While there were a few very popular activities (e.g. the video, a few of the worksheets) no two students selected the same combination of activities. As mentioned above, I was often surprised at the activities students chose, but choice certainly changed the atmosphere in the classroom.

One of the non-academic goals for the unit was for students to become more skilled in planning their time and making good academic decisions. One student who did poorly at this did have this learning experience through the unit. She commented on her self-evaluation that:

From my answer in number 3 the grade that I would have received shows that I had a hard time in this unit yet I was able to do this work. Knowing that I did not do my best I am not expecting to receive an A but I do feel that this unit showed me a little about myself. That when I go to college I will not have a push so if I don't start within myself I won't make it. Even though I may not have learned much through this unit I had really got to know myself. I may have set my mind to not caring for this unit but I do thank you because talking with my parent and evaluating myself I have realized that I need to get more focused and have a push for myself and not wait for someone to push me!

For this student, fulfilling the lower tiers of Maslow's hierarchy was more important than participating fully in the class. Although this student's learning did not include all of the energy objectives for the unit, what she did learn was just as valuable. Also, in the development of healthy human beings, sometimes learning has to happen in

other areas before content can be addressed. Incidentally, this student will be the first ever in her family to attend college.

POTENTIAL FOR LASTING EFFECTS

Due to the engagement and relevance of some activities, it is expected that students will retain some of the learning from this unit. For example, students who participated in making an electrical current were so involved tactilely and mentally that it is possible that both semantic and episodic memory systems were activated, increasing the chances of retention. Likewise, the concepts tied to activities with obvious relevance—for example making connections between energy bills and the students' energy use—might also potentially be retained. Conversations with some students about current events well after the unit was over also suggest that retention will occur at least in these students, who were able to make connections from the unit to events beyond the school.

As a final anecdote regarding student learning and retention: I attended my students' prom in June and ran into one of the students from this class. "Ms. LaSovage! I have to tell you what I saw on MTV!" There she stood in the banquet hall, in her formal gown and with her date by her side, and excitedly told me that the station she had been watching had talked about the issue of global warming—and that she knew what they were talking about. It doesn't get any better than that.

WERE THE GOALS OF THE UNIT MET?

Some of the objectives for this redesigned unit were clearly met, while others were either partially met or results inconclusive. A summary of objectives and outcomes is in Table 10.

Table 10: Summary of Unit Success

Goal	Met/Not Met	Evidence
Increase student motivation and engagement by providing student choice	Met and Not Met	Initial motivation was good as evidenced by student participation and endurance; subsequent motivation was absent
Increase relevance and hands-on activities in the unit	Met	Many new and existing activities were incorporated in the design of the unit; post-survey responses imply that students did perceive energy to be related to their lives
Allow students to learn and demonstrate learning through multiple intelligences	Met	Activities incorporated multiple learning styles and designs to appeal to multiple intelligences; Emphasis on oral defenses may have limited some demonstration of learning through other intelligences for some C level activities
Increase authentic learning by holding students accountable for their learning	Attempted	Oral defenses were intended to hold students accountable; not all students defended in later parts of the unit; student perceptions showed little evidence of personal accountability
Increase student mastery of content	Met*	Pre- and Post-Test scores significantly improved on most areas; *some areas did not improve; overall scores were mediocre

Table 10: Continued

Goal	Met/Not Met	Evidence
Increase retention of learning	Inconclusive	In some situations, conditions were right in maximize the potential of retention, however, I will not have the opportunity to assess these students in the future. Anecdotal evidence suggests that some students will retain and use information and skills learned in the unit.
Meet other course content objectives and behavioral goals	Met	Some students became more aware of time management; most students stated willingness to change behaviors outside of class; post-test and post-unit survey answers show an increase in understanding of global effects for personal energy use

HOW DO THIS YEAR'S DATA COMPARE TO LAST YEAR'S?

An attempt was made to compare results from this year's unit test and post-test to results from last year (when the unit was taught in a traditional format). Comparisons are shown in Appendix D.12. An initial survey of the data yields a few points of interest:

- There is only slight difference between average Unit Test scores of the two years
- Average Post-Test scores appear to be higher in 2005-2006 (the year of this study)
- Average scores on individual Post-Test questions show varied results (Table 11)

Table 11: Comparison of Post-Test Results Between Current and Previous Years

Little difference	Question 1
Improvement in 2005-2006	Questions 2, 3, 6, 7
Lower scores in 2005-2006	Question 4

Although these comparisons are interesting, the data must be considered inconclusive due to factors such as small sample size, minor changes in the grading rubric and natural variation that exists in class composition from year to year. However, this data can serve as a launching board for questions and a basis for further studies.

Note: No statistical analysis was done on this comparison.

WILL I DO A LAYERED ENERGY UNIT AGAIN?

I have not decided if I will conduct the energy unit in a layered format or traditional format when I teach the energy unit next year. If I choose to use a layered format, I will revisit the deadline schedule and offer more structure to my students.

The almost unanimous response by students that choice was the best thing about the unit is one reason I would consider doing the unit in layered format again. Across the board students identified this as a positive feature of the unit. Not only does choice give some control to my students, who are in an age group where autonomy is a growing need, choice allowed students to feel more confident and produce better results than imposed activities. Although there are other issues to refine with layering, if I can hook the students in with choice, learning should be more likely to occur.

Regardless of the format I choose for the unit next year, I will definitely include many of the new activities that worked well this year. I believe the use of hands-on activities and activities that address multiple intelligences and learning styles did produce positive results in this unit.

APPENDICES

APPENDIX A

APPENDIX A.1

Further Discussion of Multiple Intelligences

According to Jensen (1996), Gardner defined intelligence as the ability to “1) use a skill, 2) fashion an artifact, or 3) solve a problem in a way that is valued by the particular culture of that individual.” Fetsco (2005) lists eight qualifications that must be met for inclusion as a true intelligence. Among them are that the intelligence is associated primarily in one part of the brain and that damage to that area of the brain should influence the intelligence. Also, for each intelligence, there should be an identifiable subpopulation of persons who are extremely apt in that intelligence. A musical prodigy or a mathematical savant are examples. Other requirements include that each intelligence should have its own mental processes and symbol system and should have evidence of a social and evolutionary history.

Andrew Latham (1997), citing research from Hoerr and Gardner, states that the number one caution for using multiple intelligences in school settings is attempting to incorporate all intelligences into every lesson “regardless of whether it makes sense to do so.” As Latham puts it, “Multiple intelligences theory should catalyze ideas, not impose an inflexible structure” and should be used to help cultivate skills that are valued in community and society, approach new concepts and subjects in a variety of ways and personalize instruction as much as possible. As Latham interprets, “[Gardner himself] would prefer that educators engage in thoughtful, exploratory, trial-and-error reform, not blindly accept some established MI [multiple intelligence]-based norm.”

APPENDIX A.2

Further Discussion of Learning Style Descriptions

Kolb's learning cycle has four components: concrete experience (being involved oneself/feeling), reflective observation (observing others' experience/watching), abstract conceptualizing (creating theories to explain observations/thinking) and finally active experimentation (using theories to problem-solve and make decisions/doing).

Four learning styles (accommodator, assimilator converger, or diverger) come out of this cycle, based on a learner's internal decisions in a learning situation of 1) whether to do or watch and 2) whether to think or feel. For example, an individual might generally choose to "do" (as opposed to "watch") and "feel" (as opposed to "think") would have an "accommodating" learning style. "Watching" and "thinking" is indicative of an assimilating style (Kolb, 1984; Chapman, 2006).

Kolb views a learner as preferring a single learning style (Chapman, 2006) and has described key characteristics of each style. Accommodators tend to be active, use intuition over logic, and like to connect learning to personal meaning and real life. Assimilators typically prefer to use logic over intuition, enjoy abstract ideas and respect information from expert authority. Convergers enjoy relevance and utility and tend to enjoy hands-on tasks. Divergers want to know why, enjoy hearing a variety of viewpoints and are imaginative in their problem solving (Muijs and Reynolds, 2001).

Processing Styles

Distinctions have been made between inductive learning (starting with details and then forming the big picture) and deductive learning (understanding examples by first seeing the big pictures). Global learners have also been differentiated from sequential learners. Chiefly, global learners prefer learning in large chunks and are good at synthesis. They are “big picture” learners who may seem slow until they have constructed a full understanding of an idea. Sequential learners are happy learning one piece at a time, analyze well and can deal well with partial understanding; however they sometimes miss the big picture (Muijs and Reynolds, 2001).

Existence of Preferred Learning Style

To defend the existence of the preferred learning style, Eric Jensen uses an example of how different people might respond in the high anxiety situation of being in a building on fire. Response will vary according to baseline learning style of an individual.

- 1) Visual – quickly looks around to assess the situation, locate exits and see if others are in need
- 2) Auditory – immediately starts yelling “fire!” or gives directions
- 3) Kinesthetic – starts running for the exit or grabbing others to help them out

While all people in the burning room may indeed do all three of the activities, the one which comes to mind first—the default, gives a clue as to the preferred learning style of the person, and perhaps the one that was relied on most heavily as an infant or toddler.

Complexity of Learning

Jensen claims that learning happens in context, with input preferences, by processing it and then reacting to it. Context refers to the circumstances under which learning occurs. This includes such things as temperature, social conditions, and the relationship with the presenter. Input is the form in which information is delivered or received. This may include visual means, auditory, kinesthetic, olfactory, gustatory or other forms. Furthermore, input can be internal (created in the learner's mind) or external.

Once the learner is exposed to the input, there is a great deal of variety in how the data can be processed. This includes processing globally, sequentially, analytically, multi- or single-task, concrete or abstract, left- or right-brain or others. Once processed, the mind filters the information and acts or summarizes based on a preference influenced by several factors including time, risk assessment and internal and external situations. For example, some learners will respond by finding patterns (matchers); others will intuitively identify breaks in patterns (mismatchers). Externally referenced learners will respond after assessing how they think others would have them respond. Impulsive experimental filterers are likely to respond with immediate action while analytic reflective filterers may stand back and reflect on what is learned.

Influence of Environment on Learning Style and Correlation to the Classroom

Learning styles can be culturally and geographically influenced (Jensen, 1996). It may be that in order to thrive in the given culture and its corresponding environment, certain learning styles are favored from infancy. For example, rural learners tend to be more field-dependent (“need to be there”) than urban learners, who can learn out of context. Other trends observed are that Midwesterners and Northern Asians are likely to be matchers while more mismatches are found in learners from Australia and Israel; Native Americans and a high percentage of blacks are right hemisphere dominant, and women tend to be more auditory than men (Jensen 1996). Although the bell-curve of preferred learning style may indeed be culturally influenced, it is very important not to make stereotypes based on any cultural interpretations. The brain is unique to the individual, and even within populations of similar culture there is variation.

Jensen intimates that a student’s preferred learning style can influence success in school. According to Jensen, the traditional school setting favors a field-independent, reflective, cognitive style. This virtually guarantees success for students who have a learning style that matches that while it will likely “doom a learner to failure” whose learning style is incompatible with it.

The nonstatic and complex nature of learning styles makes applying elements of it in the classroom a less than straightforward matter. As we have seen, the literature suggests that trying to identify and teach to one student’s particular learning style may not actually benefit that student. However, teaching to solely one learning style will almost certainly cause many students to be unsuccessful.

APPENDIX A.3

Definitions and Further Discussion of Motivation

Wiseman and Hunt (2001) define motivation as “an internal state that arouses students to action, directs them to certain behaviors, and assists them in maintaining their arousal and action with regard to behaviors important and appropriate to the learning environment.” Bigge (1971) states that motivation happens, “When a person develops a state of tension resulting from unsatisfied need.” Piaget believed motivation to be the result of an individual trying to reconcile some internal disequilibrium (Henson and Eller, 1999). More simply, Fetsco (2005) defines motivation as “a mental process that activates, directs, and maintains behavior.”

The actual impetus for any motivation may be internal (a response to mental and physical states), external (a response to the environment) or a result of the interaction of the environment with internal states (Fetsco, 2005). The consequences are often apparent in the classroom; Henson and Eller state, “Those [students] who are unmotivated are rarely successful academically, whereas motivated student are typically the best students, both academically and socially” (Henson and Eller, 1999).

Wiseman and Hunt (2005) warn that “teachers cannot count on students being intrinsically motivated on every task that they present before [the students].” Although motivation can be influenced by variations in classrooms and instruction, Fetsco (2005) similarly states that “It is impossible to predict precisely how an instructional activity will affect individual students.”

APPENDIX A.4

Further Discussion of Maslow's Hierarchy of Needs

Examples of physiological needs are those required for basic survival such as food, water, and shelter. Safety needs include physical safety as well as the security of knowing what to expect. The need for belonging and the need for esteem involve having supportive interactions with other people and status in a group. Esteem also includes one's own view of self. Self-actualization, at the top of the pyramid involves development of a person's individual abilities and talents.

Two additional needs are intellectual needs and aesthetic needs (Fetsco, 2005). Although some sources include these as part of the pyramid (situated between esteem and self-actualization), Fetsco interprets these to be parallel hierarchies which are filled in tandem to other needs. Often an intellectual or aesthetic need can support the basic needs. A male student who knows about basketball may find a group of friends with similar interests, thus fulfilling a need for belonging. A student who writes well may receive esteem from her peers and teachers, which may also increase her self-esteem.

All people, and thus all learners, will have an inescapable drive to satisfy needs. How individuals seek to meet these needs, however, may differ. Cultural and geographic differences exist in how people fulfill some of the basic needs; people in China have different diets and housing than people in Norway. Differences in culture can also influence other needs. For example, to meet the needs of acquiring esteem in a community, a student from rural Montana may decide to become a rancher. Conversely,

a student from Silicon Valley might earn the esteem of others by pursuing a career in computer engineering.

To apply this concept to the classroom, educators should be aware that there is often more going on in a student's life than what is externally evidenced in the few hours they are in the classroom.

APPENDIX A.5

Teacher Influence on Student Motives

Although motives are somewhat fixed, they are not immutable. Henson and Eller claim that “teachers can increase achievement motivation in students by encouraging them to be independent, to accept personal responsibility for their performance, and to accept some goals that require taking some risks.” This must happen, of course, in a positive and safe environment for the student, and does not bring about change overnight. Experiencing success can also increase motivation, even in students with low level of achievement motive. Layered curriculum could provide an opportunity to positively influence the motives of some learners.

APPENDIX A.6

Stability and Controllability

Stability, the second dimension of Weiner’s theory, refers to whether a cause is fixed (such as ability or teacher bias) or variable (such as mood or luck). Controllability, the third dimension, refers to whether the cause can be controlled by the learner. Teacher bias is considered stable and uncontrollable, for example, while luck is unstable and uncontrollable. Receiving help from others is unstable yet controllable.

APPENDIX A.7

Effects of Student Perception and Self-Concept on Motivation and Success

Perceptions can have outward consequences as well as internal effects. Certainly, continuous frustration in a certain venue can have negative impact on the learner's production, but it can also impact a learner's self-concept, self-esteem and self-efficacy. The definition for self-concept used by Muij and Reynolds (2001) is "A person's perceptions of him/herself, formed through experience with the environment, interactions with significant others and attributes of his or her own behavior." Students may have separate self-concepts for a number of areas. For example, a student might consider herself good at sports and average at English. Self-esteem is defined as "a personal judgment of worthiness that is expressed in the attitudes that individual holds towards him or herself" (Muijs and Reynolds, 2001). Both self-concept and self-esteem can influence motivation. Although not entirely, these views of self can be influenced by past experience.

Research of Purkey suggests a strong relationship between self-concept and school achievement, with academic self-concept more strongly related to success or failure than self esteem. Whether achievement affects self-concept or self-concept affects achievement has not been determined. However, improving the view a student has of his or her abilities is likely to improve academic performance (Muijs and Reynolds, 2001).

In my own experience, I have seen that students who are in classes perceived to be the "dumb" classes are more likely to give up instead and consider themselves "dumb"

than are students in perceived higher-level classes. Muijs and Reynolds (2001) suggest having high expectations of students, providing structure and empowering students with responsibility and autonomy can help improve their self-view.

The belief that a student has about himself and his competency is also related to self-efficacy. As expected, this influences learning as well. Students with high self-efficacy “may be willing to try harder behaviors, and succeeding at these harder behaviors can elevate their self-efficacy” (Fetsco, 2005).

APPENDIX A.8

Relationship of Success to Future Success

Jensen (1996) and Wiseman and Hunt (2001) concur: students must experience success in order to maintain motivation. States Bigge (1971), “Although occasional failure is not inimical to the progress of learning, fairly regular success is a must...A continuous succession of failure discourages students to the point where frustration blocks further effort.” According to Wiseman and Hunt (2001), “Success, even in small amounts is a more potent motivator for most students than failure.” In Jensen’s words, “Learners need to know that it’s possible for them to succeed. Regardless of the obstacles or how far behind, hope is essential” (Jensen, 1996). Bigge further intimates, “An uninterrupted series of successes may be as bad as an uninterrupted set of failures...especially when goals are too easy and students are left with much extra time and energy.”

Wiseman and Hunt summarize: “Achievable goals are more likely to sustain motivation by students that are goals whose ends seem impossible to attain.” This has ramifications for the classroom teacher. Constance Cloonan, a former New Jersey Teacher of the Year considers, “In motivating students, it is vital to create an academic environment that is highly challenging but within the intellectual reach of the students” (Henson and Eller, 1999).

APPENDIX A.9

Authentic and Performance Assessment

According to Meyer, performance and authentic assessment are different. In both, the student does demonstrate the actual behavior that the assessor wants to measure in a format that requires no inference. However, authentic assessment does so in a real-life context (Taylor, 2003).

Wiggins makes no distinction between authentic and performance assessment, but qualifies that “performance assessments permit pupils to demonstrate what they can do in real situations, rather than articulate how a task or skill should be completed” (Taylor, 2003). Similarly, Muijs and Reynolds (2001) describe performance assessments as those which measure learning directly, as opposed to by using proxy items. Henson and Eller (1999) feel that authentic assessment is aimed at preparing students for life—that is, assessment that measures those skills that citizens need to perform those tasks common in daily life.

Taylor (2003) also applauds performance assessment: “Performance assessment can provide another avenue for pupils with disabilities and other pupils who do poorly on certain tests an alternate way to demonstrate mastery of skills” (Taylor, 2003).

APPENDIX A.10

Study of Energy in Various Disciplines

Being such an irreplaceable component of living and nonliving systems, studies of energy occur in nearly all the science disciplines. Biology content involves energy through studies of photosynthesis, respiration, ecosystems and food chains. Physical sciences deal primarily with quantifying energy and looking at mechanical conversions. For example, a physics student might be asked to compare the relative amounts of potential and kinetic energy of a roller coaster car at the top of a hill and at the bottom. Specific forms of energy such as electricity are also studied as specialties. Even beyond the science curriculum, energy is a prevalent topic in other content areas. For example, social studies courses can involve a discussion of energy when discussing “the energy crisis,” a national “energy policy” or international conflicts caused by fossil fuel shortage. The prevalence of energy in multiple disciplines clearly demonstrates that the concept of energy is an important part of both human life and human culture.

APPENDIX A.11

Detail of Energy Sources for Southeast Michigan

For electricity production in southeastern Michigan, coal, oil and gas combined provide 79.2% of the electrical power from Consumers Energy (Consumers Energy Bill, October 1, 2004 – September 30 2005). Specifically, coal provides 57.1% of energy locally and an average of 71.3% of energy in the five-state area. Fossil fuel use is up from a similar period in 2003, and particularly the use of coal is greater.

It is interesting to note that the original energy source for a fossil fuel is actually the sun. It is through photosynthesis that the original light energy was converted to chemical energy which is later released through combustion. This is why fossil fuels have been referred to by some as “buried sunshine.” However, solar energy and energy from fossil fuels are considerably different in their energy conversions and impact on the environment.

APPENDIX A.12

Student Misconceptions about “Renewable Resources”

Several common examples exist to show that the terms renewable and reusable are not interchangeable. For example, copper metal is *reusable*. A copper coin can be melted and turned into a copper wire. However, copper, is not *renewable* since no more copper is being made in the earth. The total source of copper is finite. On the other hand, sunlight is *renewable*. We can reasonable expect that the sun will continue to send electromagnetic radiation to earth tomorrow and indefinitely. However, technically speaking, the sunlight from today dissipates into the environment (mostly as heat). This energy, unless somehow stored, can not itself be *reused* again tomorrow. Once absorbed or reflected, our ability to use it is lost.

Even with a multitude of similar examples, a percentage of students still retain the misconception that renewable is the same as reusable. In many situations I find that many of my students misuse common words and do not pay attention to language details. This may be one reason this misconception is so lasting.

APPENDIX A.13

Values and Conflict

Value systems develop through personal experience, family culture, and other influence and individuals have a tendency toward some values more than others, though the relative strength of values may change as a person ages. For the purpose of analysis, values can be categorized in such groups as environmental values, which deal with preserving or conserving the natural world, health values, educational values, aesthetic values, entertainment, economic values, and ethical and moral values which deal with what is right or wrong. In addition to learning how values influence decision-making, students should see that conflicting values are a key reason there are disagreements in environmental issues.

The decision of whether to drill or explore for oil in the Alaska National Wildlife Refuge is a good example of how conflicting values can cause disagreement. Oil prospectors, who can be assumed to have strong economic values, believe there may be a six-month supply of oil beneath the refuge and that that is worth the potential environmental risk of drilling. In contrast, environmentalists, who are utilizing a different set of values, believe the risk of damaging the fragile ecosystem outweighs the possible benefits of extracting oil.

Whether or not to build new nuclear power plants is another situation where conflicting values cause different responses to the same set of facts.

APPENDIX A.14

Global Warming in Politics and the Media

The global warming issue spurred Senators John McCain and Joseph Lieberman to sponsor the bipartisan McCain-Lieberman Climate Stewardship Act to encourage a national reduction in greenhouse gas emission. Also, Senator John McCain has spoken out in favor of replacing traditional coal-burning plants with nuclear power plants, which do not emit greenhouse gases. Further, since the implementation of this energy unit in this study, former Vice President Al Gore has released a documentary called “An Inconvenient Truth,” which deals with our dependence on fossil fuels and the causes and consequences of global warming. Popular cinema also put climate change front and center, Hollywood-style, in the recent film “The Day After Tomorrow.”

APPENDIX A.15

Background on Bloom's Taxonomy

A well-accepted explanation of the hierarchy of thinking skills was outlined by Benjamin Bloom. Bloom's taxonomy of the cognitive domain classifies six thought processes by the complexity of thought involved (TenBrink, 1974). The lowest level is knowledge, and deals with fact memorization. Comprehension involves not only remembering facts, but understanding. Comprehension can be measured in whether a student can explain an idea in his or her own words or can provide examples independent of those he or she has already been provided with. According to Bloom, application is the next complex level of cognitive thought. Application deals with using knowledge and comprehension in a new situation. For example, a student learning to read can apply a learned rule of phonics to a word he or she has never before encountered. Analysis is the next level of the taxonomy, followed by synthesis. Analysis involves breaking down given data into its component parts; an example would be separating a newspaper article into elements of fact or opinion (TenBrink, 1974). Synthesis, on the other hand, involves combining information to make a new whole. Constructing personal opinions given a set of facts and events or describing patterns in an information set can both be considered synthesis. The top layer of Bloom's cognitive hierarchy is evaluation. This involves a student using other levels of thought to final come to a value assessment of some item and come to a fuller understanding of it.

APPENDIX B

OBJECTIVE SET I (PINK): Activity Choices

Objective Set I: Energy Forms and Transfers and Evaluating Energy Sources

- > List common forms of energy.
- > Describe how electricity can be generated using magnets and coiled wire.
- > Trace the path of energy through the nine common energy sources.
- > Consider pros and cons of the nine common energy sources.
- > Define and distinguish between renewable and nonrenewable energy resources.
- > Evaluate energy sources based on cost, availability and environmental impact.
- > Investigate and be able to intelligently discuss an alternative energy source.

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher Sig.
I	C	1	Journal Entries: Complete on day assigned and get stamped same day; submit as a group at the end of the week or section. 1 pt each	variable	NO	
I	C	2	Lecture 1: <i>Wind, Hydropower and Tidal Energy Sources</i> . Take notes during lecture, highlight or organize notes for homework, and be ready to OD using notes the following day.	without notes _3_ with notes _5_	YES, see details	
I	C	3	Lecture 2: <i>Fossil Fuels, Fission, and Geothermal Energy Sources</i> . Take notes during lecture, highlight or organize notes for homework, and be ready to OD using notes the following day.	without notes _3_ with notes _5_	YES, see details	
I	C	4	Lecture 3: <i>Biomass/biofuel, Solar, and Hydrogen Fuel Cell Energy Sources</i> . Take notes during lecture, highlight or organize notes for homework, and be ready to OD using notes the following day.	without notes _3_ with notes _5_	YES, see details	
I	C	5	Lecture 4 (mini): <i>Renewable vs. Nonrenewable Resources</i> . Take notes during lecture, highlight or organize notes for homework, and be ready to OD using notes the following day.	without notes _3_ with notes _5_	YES, see details	
I	C	6	Demo/Small group lecture: Generators and how they work	3	NO	
I	C	7	Demo/Small group lecture: Getting ethanol from yeast	3	NO	
I	C	8	Video: Alternative Energies--Fuels for the Future Scott Resources Earth Science (~21 minutes) Take at least 10 notes of things that are new to you. Use complete sentences.	5	NO	
I	C	9	Video: Renewable Energy Energy Australia (~24 minutes) Write at least 8 sentences noting things that are new or of interest to you.	5	NO	
I	C	10	Video: Nova: (Energy Sources) (~50 minutes) Write at least 15 facts that are new or interesting to you.	5	NO	
I	C	11	Tactile: Construct a <i>working</i> pinwheel using the directions provided by Ms. LaSavage. Write a paragraph that explains why this is an activity appropriate to this unit. You must show me your pinwheel and have your name clearly written on it.	2	NO, but must show pinwheel working	

OBJECTIVE SET I (PINK): Activity Choices

I	C	12	Tactile: Construct a second working pinwheel that is different from your first in one way. (Examples: different size, different paper, different number of blades, different shape...) Compare and contrast your observations about how each of your pinwheels works. Be prepared to OD.	3	YES	
I	C	13	Tactile: Complete the fission and fusion demos and answer the worksheet questions.	3	YES	
I	C	14	Tactile: Create an electric current using a wire and magnet. See if it matters how the wire or magnet is moved. Complete the short worksheet.	5	NO, but must show Ms. LaSovage working current.	
I	C	15	Active Reading/Textbook—Captions: Look through Chapter 11 and pay special attention to the captions and diagrams. For EACH caption, write a good teacher-style question that would help a student to get the most out of the caption. Answer all your questions.	5	NO	
I	C	16	Textbook: Read p. 278-282. Pay special attention to diagrams and vocabulary. Take notes as desired and helpful. Answer #1-3 on p. 282 completely, correctly, and with complete sentences that tell the question and the answer. Be prepared to submit and OD	5	YES	
I	C	17	Textbook: Read p. 287-293. Pay special attention to diagrams and vocabulary. Take notes as desired and helpful. Answer #1-5 on p. 293 completely, correctly, and with complete sentences that tell the question and the answer. Be prepared to submit and OD	5	YES	
I	C	18	Textbook: Read p. 283-286. Pay special attention to diagrams and vocabulary. Take notes as desired and helpful. Answer #1-4 on p. 286 completely, correctly, and with complete sentences that tell the question and the answer. Be prepared to submit and OD	5	YES	
I	C	19	Active Reading/Text: <i>"Our Energy Sources"</i> 1) Read 2) Highlight or underline as appropriate 3) Group the types of energy sources into two categories 4) Give pros and cons and how it works for each italicized energy source. Be prepared to OD.	5	YES	
I	C	20	Active Reading/Text: <i>"Article 5.10"</i> Read article and complete a proposition/support worksheet	5	NO	
I	C	21	Active Reading/Text: <i>"Fuel Cell Background Reading"</i> Read, highlight and take notes. Draw and label a diagram of a fuel cell. Define cathode, anode and catalyst.	5	NO	

OBJECTIVE SET I (PINK): Activity Choices

I	C	22	REQUIRED ASSIGNMENT Article: Read, then summarize, including main idea, proponents/pros, opponents/cons, values involved and key facts. Be prepared to OD. AT LEAST ONE ARTICLE IS REQUIRED. You may do more if you wish.		YES	
			Article A: "Biodiesel popularity grows"	3	YES	
			Article B: "Expert says fuels cells will benefit nation"	3	YES	
			Article C: "Firm plans state's largest windfarm"	3	YES	
			Article D: "Heat a Home with Biomass"	3	YES	
I	C	23	Worksheet: <i>Forms of Energy/ Forms and Sources.</i> Complete worksheet and know types of energy. Be prepared to OD.	5	YES	
I	C	24	Worksheet: "Our Energy Sources--After Reading Guide" Use article "Our Energy Sources" to complete worksheet. Be prepared to OD.	5	YES	
I	C	25	Worksheet: "Energy Sources Worksheet--Venn Diagrams" or "Energy Sources Worksheet--Grid"	5	YES	
I	C	26	Worksheet: "Evaluating Energy Sources" (Pros/Cons of 9 Energy Sources)	5	YES	
I	C	27	Worksheet: <i>Chapter 11 Review</i> (p. 77-78)	5	YES	
I	C	28	Independent work: Check out a Consumer's Energy Handbook from Ms. LaSovage. Flip through it. ON A SEPARATE SHEET, complete one or more of the activities in the book that relates to energy. Points variable. OD.	variable	YES	
I	C	29	Creative Writing: Choose one of our nine energy sources. Write a <i>poem, rap or short story</i> that tells in first person the path that energy takes from the original source to the electric current reaching our house. Be sure to include all forms and conversions that take place.	10	YES or present to class	
I	C	30	Musical: Write, memorize and sing a song to learn the how each of the nine energy sources works. Extra points will be added if energy transformations are included.	10	YES or sing to class	
I	C	31	Create/Linguistic: Make a crossword puzzle that includes all nine of our energy sources plus 3 additional terms. Each term must have a clue.	5	YES	
I	C	32	Create/Poster: Choose two of our energy sources. In a colorful poster, trace the path that energy takes from the original source to an electrical current. Do this for both of the energy sources. (They may be side by side on the poster.) Accuracy and aesthetics count.	6	YES	
I	C	33	Current Event: Do a current event that relates to this content and fully elaborate on why. This may be an additional current event or may be part of your regular current event. Same current event rules apply.	5	MUST PRESENT	

OBJECTIVE SET I (PINK): Activity Choices

I	C	34	Interpersonal: Play someone's game that they have written for Level B of this Objective. Write a paragraph evaluation.	5	NO	
I	C	35	Interpersonal: Talk to someone about the lab that you did for Level B. Complete and "I-LERN" form.	5	NO	
I	C	36	Interpersonal: Talk to someone about the lab that they did for Level B. Complete an "I-LERN" form.	5	YES	
I	C	37	Watch someone's PowerPoint; pay attention. OD what you learned or submit brief written response.	3	YES or written response	
I	C	38	Audio or Transcripts: Visit http://www.loe.org . For info on Fusion, see the show from February 24, 2006. For info on Hydrogen technology, see May 14, 2004. Other informatio may earn credit. Be able to discuss.		YES	
I	C	39	YOUR CHOICE: Option must be preapproved by Ms. LaSavage and must be different than existing options.			

POINT RANGE FOR THIS CLUSTER: Minimum: 40 Maximum: 50

TOTAL:

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher Sig.
I	B	1	Lab: Conduct an investigation measuring the influence on color or angle of light on the efficiency of solar cells. Write a lab report according to class guidelines.	15		
I	B	2	Lab: Make an electrical current using the "baby food galvanometer" generator design provided by Ms. LaSavage or research another design. Experiment with different variables such as number of coils or magnets to see how each affects the amount of current produced. Write a lab report according to class guidelines.	15		
I	B	3	Lab: Construct a pie-plate turbine and experiment to see how the height or amount of water affects the spin. Relate this to choosing a location to have hydroelectric power plants. Write a lab report according to class guidelines.	15		
I	B	4	Create: Create a children's book illustrating how each of the 9 energy sources works. Include energy forms and transfers. Make it colorful. Must read it to at least one child after approval by Ms. LaSavage.	15		
I	B	5	Create: Create a good game that is fun to play and teaches at least 2 the objectives in Ojective Set I. Play this game with at least two groups of people. One of these groups may be from outside of class, but one must be from your classmates.	15		

OBJECTIVE SET I (PINK): Activity Choices

I	B	6	Solar Research: Research the different types of solar cells. Make a poster-sized table comparing their cost, efficiency and at least one other feature. Write a short paragraph explaining which type would be best for a homeowner to use OR present this information in a powerpoint presentation.	15		
I	B	7	Wind Research: Research what kind of wind turbines or other wind power is available to homeowners who want to generate their own electricity. Compare their cost, efficiency, energy output, wind requirements and at least one other feature. Summarize your findings. Then, make a poster-sized advertisement for the one you think would be best investment for a homeowner who has a lifestyle like yours.	15		
I	B	8	Current Event (Nuclear) Research: There is a small town in Alaska that wants to build a nuclear power facility. Find out what town and what their circumstances are and make a report to the class. Also, state whether you think it is a good idea for that town. Hint: This was in the newspaper in the last year or two.	15		
I	B	9	Solar Options: President George W. Bush made a visit to Auburn Hills on Monday, February 20th to tour a plant that makes solar shingles. Find out more about the plant and their products and clientele. Write a summary of your findings and make a brief presentation to the class. ALTERNATE: Extra points if you contact someone at the plant and interview them or if you visit the actual plant. Ask about interview requirements.	15 or more		
I	B	10	Critical Thinking Worksheet: Interpreting Observations Chapter 11 p. 80. Complete and submit answer in typed paper form.	15		
I	B	11	Money: Complete a cost analysis of wind power versus a nonrenewable power source. How much would electricity have to cost to make wind power a better option economically?	15		
I	B	12	TBD OPTION: Must be preapproved			

POINT RANGE FOR THIS CLUSTER: Minimum: 30 Maximum: 45 TOTAL:

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher sig.
I	A	1	Nuclear Research: Most of France's energy comes from nuclear power. Find out how much. Then, compare France and the U.S. in terms of energy demand, what sources they get most of their energy from, and how nuclear power plants in France are different than some of our nuclear plants. Include pie charts and other data in your presentation or paper.	20	YES	

OBJECTIVE SET I (PINK): Activity Choices

I	A	2	Solar Options: Do a little research and contact the person at Oakland University who can talk to you about OU's experiment involving solar roofing shingles on some of their campus buildings. Interview them. For credit, must provide at least 6 questions you asked and the answers given. This may be a transcript or an audio tape. Extra points if you visit the actual site.	20	YES	
I	A	3	Solar Activity: Research designs and then construct a working box oven and use it to cook a pizza or cookie. Pizza or cookie MUST BE COOKED in order to earn all points possible. Must do cooking during class or have video verification if done out of class. Note: It is winter! -Outdoor cooking is possible but may take more than one attempt!	20	YES	
I	A	4	What's best for SE Michigan?: Not all energy sources equally viable for different states. Choose two states that interest you and do research to determine which of the nine energy sources might make sense and which would not. Examples of some things you will need to research are weather, geology, natural resources, population, energy demand and topography. You may also wish to consider whether the cost of the energy source is worth it. Present your findings in the form of a letter to your mayor, a paper, or a powerpoint presentation.	20	YES	
I	A	5	Biofuels: President Bush mentioned switchgrass in this year's State of the Union Address. Research "switch grass" as an alternate fuel. Construct an informative poster, essay or powerpoint presentation that describes what it is, the life cycle, how it can be used as an alternative energy source, and why the carbon dioxide emissions from this plant are not as much a problem as those from coal burning. Decide what role, if any, you think switchgrass should play in our power production. Support your opinion.	20	YES	
I	A	6	Fuel Cells: Research more fully how fuel cells work and how close they are to mass production. Summarize your findings and your opinion. Write a position paper to summarize your findings and support your opinion on whether you think fuel cell powered vehicles will be a viable option for drivers in Southeast Michigan. Use at least 3 valid sources. Presentation options: Paper--typed, ds, 12 pt Times New Roman, approx. 3 pages. or Powerpoint--neat, no errors, minimum 8 good slides.	20	YES	
I	A	7	Lab: Complete the Lab on p. 298-299 of your book. Write a formal lab report according to class assignments. In addition, be prepared to present your findings to the class.	20	YES	

POINT RANGE FOR THIS CLUSTER: Minimum: 20 Maximum: 40

TOTAL:

OBJECTIVE SET II (BLUE): Activity Choices**Objective Set II: Consequences of our Energy Use**

- > Consider the pros and cons of common energy sources.
- > Evaluate long term consequences of current energy technologies.

NOTICE: For Level C of this set of objectives, you must choose at least one activity from each subgroup: nuclear, acid rain, global warming, and ecosystems. The remainder of the points may be from any group or subgroup.

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned
II	C	1	Journal Entries: Complete on day assigned and get stamped same day; submit as a group at the end of the week or section. 1 pt each	Variable	NO	
II-nuclear	C	2	Article Set: "Dead nuclear reactor heads south to final resting place", "Reactor Crawls South" and "Bush may alter rules on radioactive waste" Answer worksheet questions and be prepared to OD.	8	YES	
II-nuclear	C	3	Article: "Data on Nuclear Waste site may be false" Be prepared to OD a summary and your opinion as to why there is disagreement.	3	YES	
II-nuclear	C	4	Poetry: Read the Section 12.3 on toxic waste, in particular the part about Chernobyl. Then visit the website http://www.chernobyl-international.org/facts.html . You may also wish to visit http://loc.org from March 12, 2006 "Chernobyl Remembered." Write a poem from the perspective of someone who lives near a current or proposed nuclear waste site.	5	YES or Present to class	
II-nuclear	C	5	Literature: Read the short story By the Waters of Babylon by Stephen Vincent Benet. Suppose the protagonist of the story had found a letter on the desk written by the man whose office it was. What would that letter say? Write it.	10	TBD	
II-nuclear	C	6	Internet/Audio: Go to the website. http://www.threemileisland.org/downloads/396.mp3 or http://www.threemileisland.org/resource/item?detail.php?item_id=00000261 Listen to the interview with the anonymous source. Write a paragraph summary of the event and a paragraph reaction to what you hear. Be prepared to OD	6	YES	
II-nuclear	C	7	Tactile/Internet: Complete the half-life cutting activity. You may complete Part 1 or Part 1, 2 and 3. Written answers to questions will have the potential for more points.	variable- 3 to 5	YES	
II-acid rain	C	8	Alternate Textbook: Read pages 297-305 in the Chemistry in the Community Textbook. Write a 1/2 page summary, including relating acid rain to our high demand of electricity.	5	YES	
II-acid rain	C	9	Create/Poster: Research the relationship between the burning of coal and acid rain. Make a poster showing the chemicals. Include on your poster at least three ways how this can be prevented or reduced	6	YES	

OBJECTIVE SET II (BLUE): Activity Choices

II-acid rain	C	10	Mapping Activity: Complete the "Find the Rain's Fingerprint" Activity and corresponding questions.	8	YES	
II-acid rain	C	11	OPTION:			
II-global warming	C	12	Internet/Video: Visit this website: http://www.epa.gov/globalwarming/kids/version2.html Watch the video twice. Take notes if needed; be prepared to OD.	5	YES	
II-global warming	C	13	Powerpoint: Research the data supporting the connection between human activities and global warming and how scientists have gathered data that have led them to believe that global warming is impacted by human activities. Create a power point presentation with a minimum of 6 slides to present your findings.	10	PRESENT Power point	
II-global warming	C	14	Article: "Experts say: Act now on global warming" Read, then write a page summary including a) summary b) values analysis c) your response. Be prepared to OD.	5	YES	
II-global warming	C	15	Article: "Old bubbles back global warming theory" Read, summarize, and be prepared to OD or read and complete a Proposition/Support Worksheet.	5	YES or Complete Proposition/Support	
II-global warming	C	16	Looking at Evidence: Complete Textbook Investigation 7.1: Investigating Ice Bubbles	5	YES	
II-global warming	C	17	OPTION:			
II- eco-systems	C	18	Textbook: Read and complete the Case Study "The Snail Darter and the Dam." on p. 264 - 265 of your book. Answer the questions. Also, write an answer to how this relates to our study of energy. Be prepared to OD.	5	YES	
II- eco-systems	C	19	Research: Research one of the following: Hetch Hetchy or Glen Canyon. Summarize why there was conflict when this dam was built. Include at least 3 points from both sides of the argument, and cite the dominant values for each side. OD or present in your choice of formats.	6	YES or powerpoint or class presentation	
II- eco-systems	C	20	Current Events: Research what locations in the United States (or abroad) are having arguments about the building or removal of a dam. Choose one and summarize.	5	YES or Present to class	
II- eco-systems	C	21	Art and Persuasion: Create a persuasive pamphlet or flyer about an endangered species that might be harmed by the building of a dam. Must be a real species and a real dam, although may be current or historical. Cite resources.	5	NO, if high quality	
II- eco-systems	C	22	OPTION:			

OBJECTIVE SET II (BLUE): Activity Choices

II	C	23	Interpersonal: Talk to someone about the lab that you did for Level B. Complete and "I-LERN" form.	5	NO	
II	C	24	Interpersonal: Talk to someone about the lab that they did for Level B. Complete an "I-LERN" form.	5	YES	
II	C	25	Watch someone's PowerPoint; pay attention. OD what you learned or submit brief written response.	3	YES or written response	

TOTAL:**POINT RANGE FOR THIS CLUSTER: Minimum: 45 Maximum: 60**

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned
II	B	1	Internet or Library Research: Look up these three key events in nuclear power history: Chernobyl, Ural Mountains, Three Mile Island. Make a table to compare and contrast them in terms of date, location, cause, short and long-term effects, and publicity.	10		
II	B	2	Internet/Creative Writing: Go to the following two websites and listen to the interviews. http://www.npr.org/templates/story/story.php?storyId=4502656 and http://npr.org/templates/story/story.php?storyId=1115530 Write a creative piece from the perspective of someone who was born in Chernobyl on the day it happened or from the perspective of someone who gave birth in Chernobyl on the day it happened. It can be a diary entry, a memory, or a poem. Be prepared to share.	15		
II	B	3	Internet: Visit this site about a girl who bikes through Chernobyl. http://www.kiddofspeed.com/chernobyl-revisited/chapter7.html Write a 3/4 - 1 page response to what you have seen. Do you think she is smart or stupid to do what she does?	10		
II	B	4	Worksheet: Critical Thinking--Agree or Disagree; Chapter 11 p. 81	10		
II	B	5	Go to http://www.loc.org and read or listen to " Recycling Nuclear Waste " from March 12, 2006. Write two letters to the editor of a newspaper. One letter should be in support of recycling nuclear waste. One letter should be against. Use good writing and supportive evidence.	10		
II	B	6	Speech: Who is responsible for nuclear waste? Write a 1-2 minute speech that answers this question. Be prepared to present.	10		
II	B	7	Textbook: <i>Points of View</i> Yucca Mountain Waste p. 328-329. Make a statement sheet for each side which lists the main points for the pro and against arguments. Then determine which side you are on. Must be high quality.	10		
II	B	8	Lab: Conduct a lab demonstrating the effects of carbon dioxide on global warming.	10		
II	B	9	YOUR CHOICE: Option must be preapproved by Ms. LaSavage and must be different than existing options.			

TOTAL:**POINT RANGE FOR THIS CLUSTER: Minimum: 20 Maximum: 35**

OBJECTIVE SET II (BLUE): Activity Choices

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned
II	A	1	Laws and Regulations: Research the current standards of emission for coal-burning power plants in Michigan and in the United States. Are they all the same? Are there loopholes? have there been recent changes? Present your findings in a powerpoint presentation to give to the class.	20		
II	A	2	Essay: Research and answer this question, "Is nuclear power a good choice?" Defend your opinion in researched essay. Must cite at least 3 references, at least one NOT from the Internet. Typed, d.s. 12 pt. Times New Roman	20		
II	A	3	Essay: China is a developing country, but quite close to being developed. Although their per person use of energy is lower than the U.S., they have a lot of people and the potential to cause a lot of pollution by their increased use of coal. In a researched essay, answer this: "Should developing and developed countries be held to different standards?" Must cite at least 3 references, at least one NOT from the Internet. Typed, d.s. 12 pt. Times New Roman	20		
II	A	4	Politics: What is the Kyoto Protocol? Research its history and current status. Then answer: Do you think the U.S. should have voted in favor of the treaty the first time around or not? Do you think the U.S. should ratify it now or not? Explain your position. Must cite at least 3 references, at least one NOT from the Internet. Typed, d.s. 12 pt. Times New Roman	20		
II	A	5	Current Legislation: Read through the material and do additional research on the Congressional bill proposed jointly by Senators John McCain and John Kerry. Write a letter to your Senator expressing your opinion on this piece of legislation. *Details for letters available. Must have final draft approved by Ms. LaSavage and must send letter to your senator or representative for full credit.	20		
II	A	6	Historical Event: Hoover Dam is a large and historically-significant manmade dam. Hoover Dam First, write a 1 page summary of the details and history of Hoover Dam. Then, choose one of these two questions to answer in a 1-2 page typed essay: A) Do you think Hoover Dam should have been built? Why or why not? B) Which is more important to the well-being of America--providing electricity or protecting the environment?	20		

OBJECTIVE SET II (BLUE): Activity Choices

II	A	7	Health: Research and find out about the "children of Chernobyl" or find out general information about acute and chronic radiation poisoning. Summarize in 1-2 pages. Include references. Then write a 1 page response what you think the safe limit for radiation is for your neighborhood. Cite references.	20		
II	A	8	Historical Figure: Do a little bit of research to find out who Edward Abbey was. Then read the interview he gave in 1982 at http://www.canyoncountryzephyr.com/archives/abbey-interview.html Answer one of these two question in a well-written, typed essay A) Do you think Edward Abbey was ahead of his time in his thoughts about the environment? Why or why not? B) What public figure of today's time do you think is most like Edward Abbey. Why?	20		
II	A	9	Go to http://www.cartermuseum.org/edu_guides/porter/teaching_guide/making_statement/making_a_statement.htm or link to the Making A Statement and The Place No One Knew page. Really take your time going through the pages. OPTION A: Complete the "Defending the Environment" (photography) activity. OPTION B: Essay: Should a this Dam have been built? For option B you MUST have two additional sources, and at least one of these must be a non-internet	21		

TOTAL:**POINT RANGE FOR THIS CLUSTER: Minimum: 20 Maximum: 60**

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OBJECTIVE SET III (GREEN): Activity Choices

Objective Set III: Energy Conservation and Personal Energy Choices

- > Evaluate personal energy use.
- > Describe ways to conserve energy.
- > Identify and explain reasons to promote energy conservation.

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher Sig.
III	C	1	Journal Entries: Complete on day assigned and get stamped same day; submit as a group at the end of the week or section. 1 pt each	Variable	NO	
III	C	2	Textbook: Read p. 287 - 294. Answer #1-5. Use complete sentences that indicate the question and the answer. Do not do this if you have already chosen it in a previous objective set.	5	YES	
III	C	3	Video: Green Fingers List 7 things that were suggested to conserve resources. Put a star by one that you think you could do.	5	NO	
III	C	4	Ownership: Bring in your energy bill. Acceptable: DTE, Consumers Energy	2	MINI	
III	C	5	Create: Using your energy bill, make a list of 10 questions that could be used on a test in this class. Must have your energy bill to do this.	3	NO	
III	C	6	Worksheet: Complete the "My Energy Bill Worksheet." Be prepared to OD.	5	YES	
III	C	7	Mini-lab: "What feels colder?" Be prepared to OD.	3	YES	
III	C	8	Worksheet (you make): Draw pictures showing the movement of heat in during hot and cold conditions for igloos, mud/adobe houses and space shuttles. You may use arrows for heat flow. Accuracy counts. *Some research required. Be prepared to OD	5	YES	
III	C	9	Article: "How high can heating bills go? Brace yourself" Read article and complete a Proposition/Support Worksheet.	6	NO	
III	C	10	Article: "It's Easy Being Green" Read article and complete brief worksheet. OD	5	YES	
III	C	11	Current Terms and Technology: Find out what an "energy vampire" or "ampvamp" is. You might start by looking at http://www.loe.org and listening to the program from March 12, 2006. Be ready to summarize, relate to your life, and OD. Also, try lookin at April 26th.	5	YES	
III	C	12	Current Event: Do an extra current event dealing with this objective, or add points to this week's current event by finding an article on this topic.	5	MUST PRESENT	

OBJECTIVE SET III (GREEN): Activity Choices

III	C	13	Tactile/Interpersonal: Read p.389 and make your own Wind Tester. Go home and test 8 windows or exterior doors with your wind tester. Tell your parent what you found out and share the information from p. 389. Bring back documentation in the form of a statement and signature.	10	YES, and parent signature	
III	C	14	Interpersonal: Play the game that someone made. Write a 1/2 page evaluation.	5	NO	
III	C	15	Interpersonal: Talk to someone about the lab that you did. Complete and "I-LERN" form.	5	NO	
III	C	16	Interpersonal: Talk to someone about the lab that they did. Complete an "I-LERN" form.	5	YES	
III	C	17	Watch someone's PowerPoint; pay attention. OD what you learned or submit brief written	5	YES or written	

TOTAL:
POINT RANGE FOR THIS CLUSTER: Minimum: 25 Maximum: 40

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher Sig.
III	B	1	Lab: Heat bulbs or Light bulbs? Complete the Energy Efficiency of Light Bulbs lab. Write a lab report according to class guidelines.	15		
III	B	2	Lab: Insulation--Keep my pop hot! Complete the insulation lab. Write a lab report according to class guidelines.	15		
III	B	3	Create/Take Action: Make 6 energy conservation stickers. Put them in your house. Get verification. (More details upon request)	10		
III	B	4	Design: Read the two articles " <i>Natural Instinct</i> " and " <i>Case Study: A Super-Efficient Structure.</i> " Then, design an energy efficient home or office building. Include at least 10 components will help reach your goal and explain the rationale for each. Be prepared to OD or create a powerpoint to present to the class. Additional resources are available upon request.	15		
III	B	5	Cartoon: Make two different cartoons of your own covering one or more of the concepts we are learning about. You may wish to look at the FoxTrot Cartoon as a sample.	10		
III	B	6	Game: Create a game that teaches about energy conservation. Play the game with your classmates and get feedback. NOTE: Must have prior approval to select this option if you have created a game for a previous objective.	15		

OBJECTIVE SET III (GREEN): Activity Choices

III	B	7	Articles/Research: California Blackouts and Detroit Blackouts. Complete a data table to compare and contrast the problem, the causes, and the short and long term effects of each.	10		
III	B	8	Worksheet: Critical Thinking--Interpreting Data; Chapter 11 p. 82	10		
III	B	9	Personal Energy Evaluation: Document all items you use that require energy for 24 hours. Use the Consumer's Energy booklet to determine how much money you have spend on energy in that 24 hour period. Yes, if someone else washes your clothes for you it still counts!!	15		
III	B	10	YOUR CHOICE: Option must be preapproved by Ms. LaSavage and must be different than existing options.	variable		

TOTAL:
POINT RANGE FOR THIS CLUSTER: Minimum: 40 Maximum: 60

Obj	Level	Asn mt #	Description	Points Possible	Oral Defense Required?	Points Earned/ Teacher Sig.
III	A	1	TV/Video: Make a short publicity video that teaches how to conserve energy and why it is important. Should be showable quality and accurate. Suggested 2-4 minutes.	20	MUST SHOW VIDEO	
III	A	2	Personal Energy Evaluation Level 2-- EVERYTHING you use energy for 48 hours, <i>directly and indirectly:</i> Write a page response evaluating whether you think you are you a good steward of energy. Include a plan for change or a justification why you are not willing to change. Must have supporting evidence either way.	20	YES	
III	A	3	Field Investigation: Go to ABC warehouse, Home Depot, Sears or some other appliance store. Select one appliance (dishwasher, refrigerator, etc.) to study. Evaluate at least three models for energy efficiency, cost, lifespan. Write a summary and pick which one you would buy. It is okay to talk to a salesperson, but you must gather data to support your choice. For hints, see Consumers Energy Teacher handbook 7.59 or See also Consumers Energy Student Handbook p. 28	20	YES	

OBJECTIVE SET III (GREEN): Activity Choices

III	A	4	Interview or Investigation: Do research about "on demand" water heaters. Present your findings in a paper or PowerPoint presentation, including what it is, how it works and why it should save energy. Accuracy counts. OR Interview a plumber about "on demand" water heaters. For credit, you must submit at least 6 questions you asked and the answers given. This may be a transcript or an audio tape.	20	YES	
III	A	5	At Home Investigation: Complete a Home Energy Audit. Finish the worksheet. Have parent verification. Present findings to class in your choice of format.	20	YES	
III	A	6	OPTION:			

POINT RANGE FOR THIS CLUSTER: Minimum: 20 Maximum: 60**TOTAL:**

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REQUIRED COMPONENTS FOR THE LAYERED UNIT (Yellow Sheet)

Name: _____ Date: _____ Hour: _____

INTRO TO LAYERED CURRICULUM! RELAX--WE WILL LEARN THROUGH THIS PROCESS TOGETHER!

We will do this unit in three "chunks" based on the objectives for the unit. Within each objective will be three levels of activities: C, B, and A.

Generally speaking

C LEVEL activities are basic knowledge accumulation and experiences

B LEVEL activities require you to use knowledge or gather information from multiple sources

A LEVEL activities require you to evaluate, choose, decide or act

You will have the control to decide which activities you do. At the end of each Level is a required range of points. You must earn the minimum number of points to go on to the next level. If you have reached the maximum level of points you will select your next activity from the next higher level. Ms. LaSovage has some pointers for people who might be nervous about selecting what activities are best for them. Most activities are fully described, but if you have a question, ask Ms. LaSovage.

OD stands for ORAL DEFENSE. An oral defense is a one-on-one interview with Ms. LaSovage. Usually it will consist of one to four questions regarding the assignment you have completed. In order to earn credit for OD assignments, you must answer these competently. Oral defenses can be done any time within three days of doing an assignment.

These items are required for all students. They will be completed as a class, with the exception of the labs, which may be completed at any point during the unit. There may be other required assignments as we go along.

		Points Possible	Points Earned	Completion Date
R1	Energy Unit Pre-Test		/	_____
R2	Pre-Unit Survey		/	_____
R3	True Colors Activity		/	_____
R4	Multiple Intelligences Survey		/	_____
R5	Energy Unit Post-Test		/	_____
R6	Post-Unit Survey		/	_____
R7	Energy Unit Test		/	_____
R8	AT LEAST ONE LAB		/	_____
R9	Student Self-Evaluation		/	_____

Daily Planner for Layered Unit

Name: _____ (Yellow Sheet)

Date: _____ Hour: _____

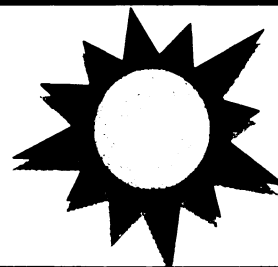
Use this calendar to help you plan your time. Although you have freedom of what you are working on, you must be constructively working at all times during the class hour. If you feel overwhelmed or have difficulty choosing what activities to do, you might want to follow the daily suggestions. These will be posted in class. Note: Activities with an asterisk (*), such as lectures and certain group activities will only be offered on that day. Activities with two asterisks (**) are required activities.

Date:	My Plan for Today Include Objective, Level and Number, as well as additional info if appropriate. For example, "I, C3 Reading notes." You may include more than one item in your plan.	My Actual Work for Today Write down what you did—either how much you finished or what you did instead of what you wrote in your plan.	My HW for tonight What do you need to do tonight to make sure you are on target to finish by the deadlines?	Teachers Initials
Monday 2/27	**Learning Styles Internet Activity **Intro to Layered Unit			
Tuesday 2/28	*Lecture 1: Wind, Hydro & Tidal *Small group Demo—generators Suggested: C13, C18, C39, C11-12			
Wednesday 3/01	*Lecture 2: Fossil Fuels, Fission, Geothermal Suggested: C13, C23			
Thursday 3/2	*Lecture 3: Biofuels, Solar, & Fuel Cell Suggested: C23			
Friday 3/3	*Video: Alt'tive Energies—Fuels for the Future Suggested:			
POINT CHECK: How many points have you accumulated? _____ How many points should you have to be in today's target range? _____ to _____				
Monday 3/6	Suggested:			
Tuesday 3/7	*Small group demo-ethanol from yeast Suggested:			
Wednesday 3/08	Suggested:			
Thursday 3/9	Suggested:			
Friday 3/10	Suggested:			
POINT CHECK: How many points have you accumulated? _____ How many points should you have to be in today's target range? _____ to _____				

APPENDIX C

FUSION -- Like the Sun

You will probably want to take a look at your book as you do this activity. In particular, look at Figure 11-13 on page 286.



Define the term "fusion"

Define the verb to "fuse"

This definition should make sense with the definition of fusion!!!! If it does not, you need to find another definition!

Some people have had surgery on their spines to "fuse" their vertebrae together. What does that mean? _____

Try it with your hands.

1. Make two small balls with clay.
2. Smash the balls together, hard enough to stick but not so hard that they aren't round anymore.
3. Want to do more? Make two more small balls with clay. Repeat the smashing.

This is FUSION. Get it?

This is what happens in the sun. A Hydrogen atom (which has one proton in its nucleus) **fuses** with another Hydrogen atom (which has one proton in its nucleus) to form Helium (which has 2 protons in its nucleus).

$$1 + 1 = 2$$

This is NOT a chemical reaction. It is a NUCLEAR reaction and large amounts of energy are released when it occurs. (That is why the sun is so hot!)

Fusion can also happen with other elements fuse together.

Try to do this with the clay:

Helium (2 protons) + Helium (2 protons) → Beryllium (4 protons)

Currently, we have not been able to reproduce fusion on Earth for more than a few seconds at a time. It takes millions of degrees to get it to happen. In the future, some people want to try fusion as an alternate energy source, but as of today it is not yet doable.

** If you are interested in learning more about what scientists have been able to do with fusion on Earth, visit <http://www.loe.org>. Then click on "Archives," then "2006 Archives" and then select the radio program from **February 24, 2006**. Ask me for more details.

FISSION – Like a power plant



You will probably want to take a look at your book as you do this activity. In particular, look at **Figure 11-8 on page 283**.

Define the term "fission" _____

Define the word "division" _____

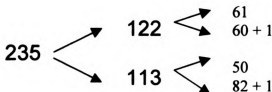
After this activity, you may see how these almost rhyming words are similar!

Try it with your hands.

1. Get a tray and some marbles and a flexible sour cream or margarine lid.
2. Put the lid down in the tray such that you can still read the label on the lid.
3. This will be slightly tricky—Put all the marbles except one into a close pile in the center of the lid. Try to keep them still.
4. Now, drop or toss the leftover marble into the pile with a little force (but not so much that it jumps out of the tray.)
5. What happened?
6. Want to do more? Repeat the process or try throwing two marbles into the pile.

This is FISSION. Get it?

This is what happens in a nuclear reactor in a nuclear power plant. A Uranium atom (which has 92 protons and 142 neutrons in its nucleus) is hit with a *really* fast neutron. This splits the Uranium into smaller particles which may either be atoms or pieces of atoms. Some of these particles will hit other Uranium atoms or be hit and split again.



and so on

This is NOT a chemical reaction. It is a NUCLEAR reaction and large amounts of energy are released when it occurs. (That is why this kind of reaction was used in the nuclear bombs dropped by the U.S. on Japan during World War II.)

Did the fission activity remind you of any game? For some people, it reminds them of pool, or billiards. Perhaps that will help you remember the difference between fission and fusion. (Fission has the letter 'i' in it and so does billiards.)

Current Event Assignment and Requirements

NAME: _____

CONSERVATION/ENVIRONMENTAL SCIENCE

PRESENTATION GROUP _____

LaSovage

Overview

Science happens all day, every day, whether by humankind or by mother nature—or by their interaction! A lot of what makes the news is directly related to the topics that we will be studying in this course. In order to make you more scientifically literate and up to date on current issues, you will be doing several current event presentations this semester. This will include finding a current article on a topic related to our course content, writing a summary of the article to submit to me, and preparing a brief yet informative presentation to share your new science information with the rest of the class.

Current events will be graded for both the written summary and the oral presentation. Presentations may include visual aids but these are not required. Part of your grade will be based on the quality of your presentation—the more effective, the better your grade.

Current Events Objectives:

Students will be able to

- Discern the main ideas from scientific articles.
- Recognize class topics in the outside world.
- Appreciate that science happens daily.
- Practice presentation skills.
- Become more aware of new ideas in science through their own investigation and by listening to their peers.

Article Requirements:

- Article must be written or published within the last 30 days
- Article must relate to content we are covering in this course * see below
- Minimum article length: ½ page of a magazine or 6 inches of columns in newspaper
- If your source from the Internet, it must be from a valid source and the source must be approved before the due date or you may not earn credit for your article. (Note: The following sites are preapproved: freep.com, CNN.com, npr.org, loe.org and MSNBC.)
- Article must be turned in at presentation or emailed ahead of time to Ms. LaSovage at: lasovageaj@southfield.k12.mi.us
- Entire article must be turned in—if it says “See Toys page 6H” then SEE TOYS PAGE 6H!
- ALTERNATIVE: News segments from broadcast news may be submitted in lieu of articles on VHS tape provided the segment is more than 30 seconds long. (These must still be written up.) Tape must be in by due date.
- Articles may not be repeated—if someone else has your article and goes first you will have until Friday to report on another article. It is your responsibility to follow through.

Topics

The chapters we will cover in this course this semester are:

CHAPTERS 13, 5, 11, 12, 6 and 7

Sample topics that are related are:

Population growth (human or nonhuman) and associated problems, water and water quality, energy sources, waste and waste management (trash), air pollution, climate

Your article *must* be relatable to one or more of our topics or subtopics and you must explain how it is related (not just list the chapter). See chapters for details or ask me.

Current Event Assignment and Requirements NAME: _____
CONSERVATION/ENVIRONMENTAL SCIENCE PRESENTATION GROUP ____
LaSovage

Requirements for Written Summary

- Must submit article with summary (or email in advance).
- Summary should be written for an **audience of your peers or parents**
- Summary should remain true to the article—facts, not imagination
- Should contain the following 5 components:
 - A concise **summary of the information** in the article
 - A description of **how and why the ideas in this article will affect you or are presently related to your life**
 - Your clearly stated **opinion or reaction** to the article content
 - An expanded explanation of **how this article relates to course content—not just the number of the chapter—expand on it!**
 - An **analysis of the values involved** in the issues of the article should be included. (For values background information, see p. 20-21 of your textbook.)
- Finally, **NO PLAGIARISM!! Copying the words and phrasing of another writer is a violation of the code of conduct and the law and will earn you a zero.**

Requirements for Presentation

- Student has an appropriately serious attitude,
- Maintains good volume,
- Maintains good eye contact,
- Effectively informs class of article content and why it relates to this class, and
- Effectively informs class of values and how the article content affects the presenter

.....

NOTE: YOU MAY NOT SUBMIT THE SAME ARTICLE AS SOMEONE ELSE, SO IT IS TO YOUR ADVANTAGE TO HAVE AN ALTERNATE ARTICLE OR VOLUNTEER TO PRESENT FIRST! FIRST COME FIRST SERVED!! If two students have the same article, the second student will have until Friday to present a new article.

.....

WEDNESDAY IS CURRENT EVENT DAY ! I am in group

Your articles will be due every other week on Wednesday. The class will be in two groups so that we will hear current events every week.

MY DATES ARE:

- | | |
|----------|-----------|
| 1. _____ | 8. _____ |
| 2. _____ | 9. _____ |
| 3. _____ | 10. _____ |
| 4. _____ | 11. _____ |
| 5. _____ | 12. _____ |
| 6. _____ | 13. _____ |
| 7. _____ | 14. _____ |

INTERPERSONAL LEARNING *EDUCATIONAL RESPONSE NOTE*
("I-LERN")

Name: _____

Date: _____ Hour: _____

.....

Circle one:

I am talking to someone about a project he/she did.

I am talking to someone about a project I did.

I am talking to someone who did the same project I did.

.....

Complete:

My name is _____.

The person I am talking to is _____.

We are talking about _____.

.....

Complete at least two of the following:

I asked this question:

I answered this question with this answer (include the Q and the A):

I learned:



Light bulbs...or *Heat* bulbs?

The purpose of this investigation is to compare the efficiency of different light bulbs by measuring their relative heat output over time.



Safety Concerns:

- Light bulbs are made of glass and are fragile. If broken, they can cut you or others. Be careful when handling bulbs and never force a bulb.
- We are using electricity today. Do NOT stick your finger or ANY other object in the light socket except the light bulbs. Do not conduct this investigation near water. Do not touch bare or exposed wires. You risk danger of shock or electrocution.
- Be aware of your surroundings. If the plastic jar is jostled, it can fall off causing a potential hazard.
- After the experiment, make sure the temperature is back in the “safe zone” of the thermometer before removing the plastic cover. Do not touch the light bulbs until they are cool. Make sure the light is unplugged before removing bulb.
- The wood base for the lights may be rough. Handle carefully to avoid getting splinters.

Basis/Key Questions behind the lab:

The bulbs are equally bright. (They have the same number of lumens, which is what we use to measure this.) One of the bulbs uses less energy to make that same brightness. If one light uses only 14 watts to make 900 lumens and another uses 60 watts to make 900 lumens, what happens to the other 46 watts? Where is the extra energy going? The extra energy is given off as heat. How do we know that? We can measure and compare the change in heat caused by each light bulb in a controlled experiment. How does this relate to our use of energy? How does this relate to conservation? How much money can be saved if a household switched from incandescent lights to fluorescent lights? What are other benefits of such a switch? What are the concerns?

These two websites have information comparing bulb efficiencies and economic savings:

<http://www.mge.com/home/lighting/efficiency.htm>

<http://www.mge.com/home/lighting/cost.htm>

Vocabulary: lumen, watt, power, efficiency, light, heat, incandescent bulb, fluorescent bulb, halogen bulb

.....

Set Up:

1. Clear off a table so you have a clean, safe workspace.
2. Get **three** wooden bases, and **three** plastic containers. Try to get containers that are identical. (Can you say why this is important?) You will also need **three** plastic suction cup thermometers. These may or may not already be in the plastic jars. (**over**)

Light bulbs...or *Heat* bulbs? (Continued)

- Put the thermometers inside the plastic jars so they are in the same place in each container. There may be a red circle to show you where to put them. (Can you state why it is important for the thermometers to be in the same positions?) If they do not stick, you may moisten the suction cup slightly with water from the sink. Do not lick them!
- Now set up the apparatus as shown in the picture below, but with three set ups. Each of the three set ups should have a different kind of lightbulb. The bulbs we will use are an **edison™ 60 halogen bulb** (900 lumens, 60 watts), a **Commercial Electric™ Ultra Mini Spiral Lamp** (900 lumens, 14 watts (60 watt equivalent)) and a **Philips DuraMax Long Life Sparkling Clear** (900 lumens, 60 watts)
- Turn on each set up to make sure that it works. If not, try changing outlets or check to see that the bulb is screwed in properly. Immediately turn it off again.
- Before you begin the actual testing, make a data table to receive your data. Refer to the purpose of this lab and to your teacher for help in this. You will need a timer or stopwatch during the data collection.
- Conduct the lab and gather data. When finished, wait until the temperature returns to the “safe zone” before handling the bulbs and putting them away.
- Get a “Simple Lab Write Up” from the crate. Write a report according to the guidelines and turn it in. A graph is required for this lab.



Figure 5: “Light Bulbs or Heat Bulbs?” Lab Set-Up

Proposition/Support Outline for Informational Text

Name: _____

Date: _____ Hour: _____

Title of Reading: _____

**Proposition:
(thesis)**

--

Support:

1. **Facts** *(true, qualitative statements relevant to the thesis)*

2. **Statistics** *(true, researched, quantitative statements relevant to thesis—look for numbers)*

3. **Examples** *(real-world occurrences, happenings, scenarios relevant to the thesis)*

4. **Expert Authority** *(what experts and accredited research institutions tell us, based on research)*

5. **Logic and Reasoning** *(cause and effects, bringing the information together—why the supporting information really does support the thesis)*

(adapted from Beuhl, 1995)

How to Make a Pinwheel

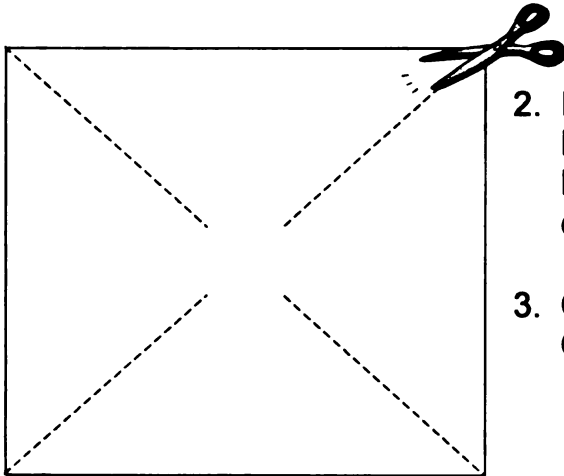
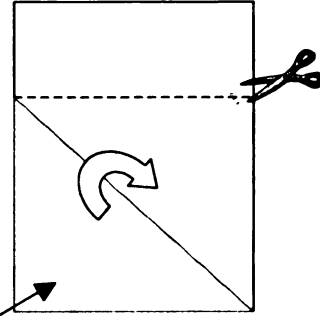
Please return this sheet when you are finished!

1. Get a sheet of paper and make a **square**.
(Remember making “cootie-catchers” or “fortune tellers”? Start out like that.)

HINT:

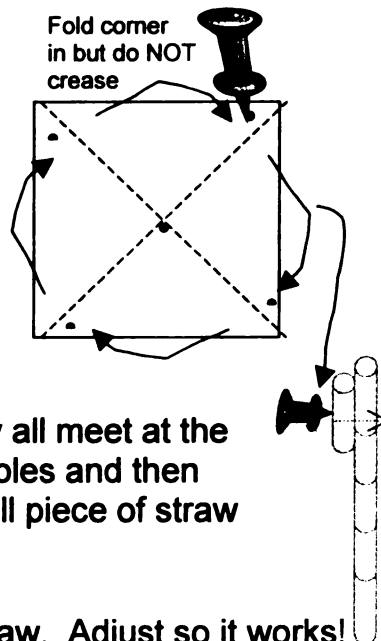
(Smaller paper sometimes works better than a whole sheet)

Fold up one corner and line up the side. Geometrically, this makes an even $\frac{1}{2}$ square. Fold and tear or cut the extra pieces. Note: This must be done using a right triangle or you will not end up with a square!



2. Lightly fold your square diagonally both ways. Crease it just enough to be able to see the line you are going to cut.
3. Cut along your lines, but **DO NOT CUT ALL THE WAY TO THE MIDDLE!**

4. Now, with a pen or marker, make a dot on one corner of each triangle and one dot in the middle. These are your guide points.
5. Using a pushpin, put a hole in each of your dots.



6. Now, fold in each of the blades so that they all meet at the center hole. Stick the pin through all five holes and then pierce it gently through both sides of a small piece of straw that has been cut from your longer straw.
7. Now stick the pin through the remaining straw. Adjust so it works!

FORMS OF ENERGY

All forms of energy fall under two categories

POTENTIAL

Potential energy is stored energy and the energy of position (gravitational)



CHEMICAL ENERGY

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

NUCLEAR ENERGY

Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

STORED MECHANICAL ENERGY

Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

GRAVITATIONAL ENERGY

Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational potential energy. When the water is released to spin the turbines, it becomes motion energy.

KINETIC

Kinetic energy is motion - the motion of waves, electrons, atoms, molecules and substances



RADIANT ENERGY

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

THERMAL ENERGY

Thermal energy (or heat) is the internal energy in substances - the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

MOTION

The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

SOUND

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

ELECTRICAL ENERGY

Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

FORMS AND SOURCES

Most of the energy we use in the U.S. is provided by the following sources of energy.
Write the form of energy—how the energy is stored or delivered—in each of the sources:

NONRENEWABLE

Petroleum _____

Coal _____

Natural Gas _____

Propane _____

Uranium _____

RENEWABLE

Wind _____

Solar _____

Biomass _____

Hydropower _____

Geothermal _____

What percentage of the nation's energy is provided by each form of energy?

Motion _____

Chemical _____

Radiant _____

Thermal _____

Nuclear _____

U. S. ENERGY CONSUMPTION BY SOURCE

	BIOMASS 2.9% <i>renewable</i> Heating, electricity, transportation		PETROLEUM 37.2% <i>nonrenewable</i> Transportation, manufacturing
	HYDROPOWER 2.7% <i>renewable</i> Electricity		NATURAL GAS 23.7% <i>nonrenewable</i> Heating, manufacturing, electricity
	GEOTHERMAL 0.3% <i>renewable</i> Heating, electricity		COAL 22.8% <i>nonrenewable</i> Electricity, manufacturing
	WIND 0.1% <i>renewable</i> Electricity		URANIUM 8.3% <i>nonrenewable</i> Electricity
	SOLAR & OTHER 0.1% <i>renewable</i> Light, heating, electricity		PROPANE 1.9% <i>nonrenewable</i> Manufacturing, heating

APPENDIX D

ENERGY UNIT PRE-TEST**Name:** _____**Date:** _____ **Hour:** _____

- 1) List the forms that energy can be found in in the universe.
- 2) Trace the path of energy from coal to your lightswitch. Use diagram, labels and details and include every step.
- 3) Make a table with three columns: Source of energy/electricity, Pros, and Cons. Fill it in with as many energy /electricity sources as you can think of...(Energy that people use for things like lighting etc.
- 4) Who is responsible for nuclear waste and why?
- 5) What is the difference between a renewable and nonrenewable resource? Give and explain an example of each that relates to energy.
- 6) What form of energy/electricity has the least negative impact on the environment and why (c.s.) Use reasons.
- 7) List as many ways to conserve energy as you can.

ENERGY UNIT POST-TEST**Name:** _____**Date:** _____ **Hour:** _____

- 1) List the forms that energy can be found in in the universe.

- 2) Trace the path of energy from coal to your lightswitch. Use diagram, labels and details and include every step.

- 3) Make a table with three columns: Source of energy/electricity, Pros, and Cons. Fill it in with as many energy /electricity sources as you can think of...(Energy that people use for things like lighting etc.

- 4) Who is responsible for nuclear waste and why?

- 5) What is the difference between a renewable and nonrenewable resource? Give and explain an example of each that relates to energy.

- 6) What form of energy/electricity has the least negative impact on the environment and why (c.s.) Use reasons.
.

- 7) List as many ways to conserve energy as you can.

APPENDIX D.3

Student Answers to Pretest and Post-Test Question 4, by Category of Response

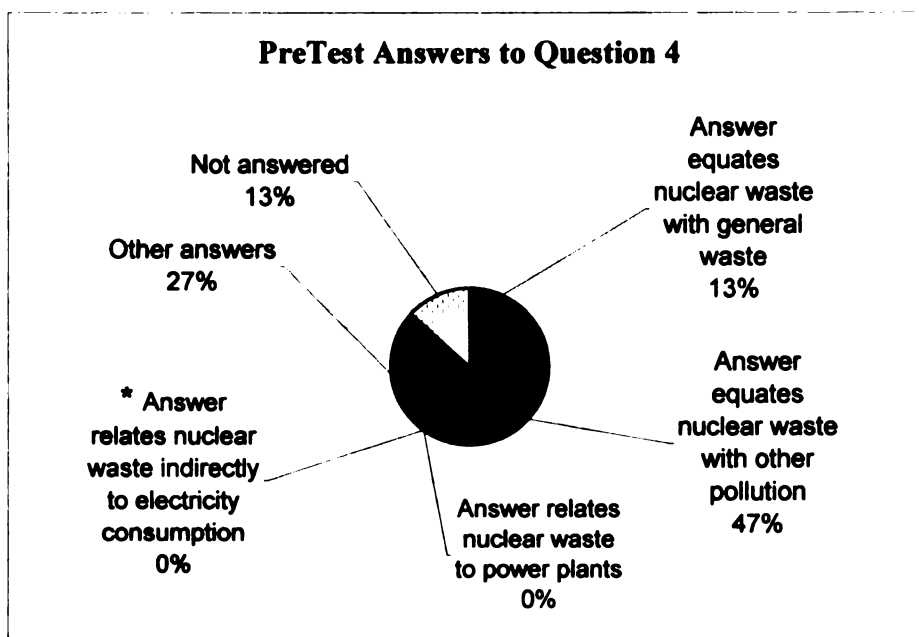


Figure 6: Summary of Pre-Test Answers to Question 4

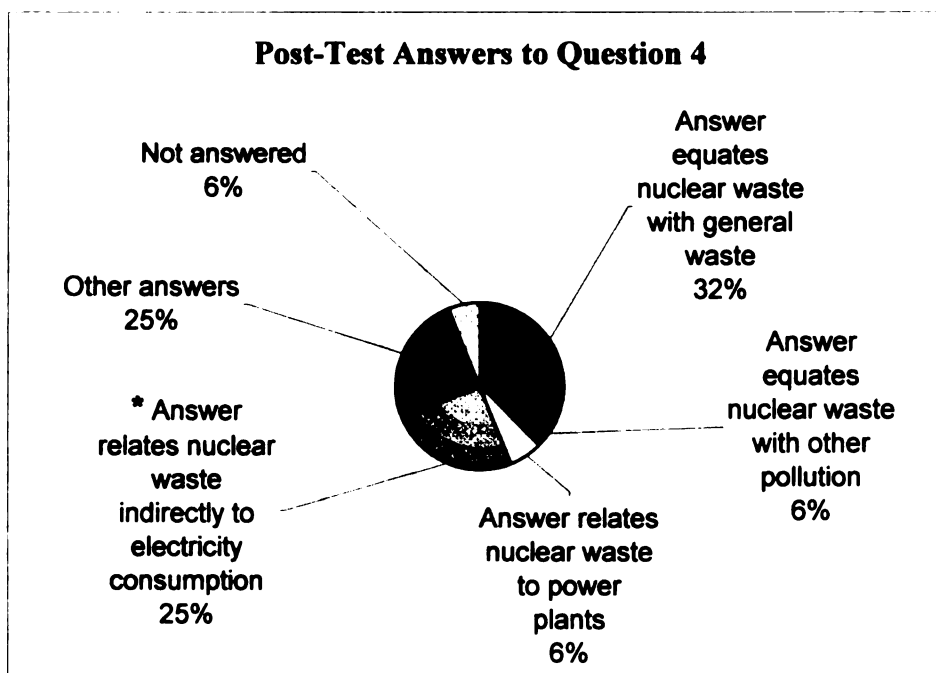


Figure 7: Summary of Post-Test Answers to Question 4

Pre-Unit Survey

Name: _____
Date: _____ Hour: _____

For each statement on this survey, select the number that best represents your thoughts. A "1" means "strongly disagree" or "not at all" and "5" means "strongly agree" or "yes, always." Please answer HONESTLY. I want to know what you think and know.

strongly disagree <--> strongly agree

Learning/How to Learn

1	I learn best when "on my own" instead of being "taught" by someone else.	1	2	3	4	5
2	Students should be able to choose how they learn	1	2	3	4	5
3	It is easier to learn when you are given a lot of choices.	1	2	3	4	5
4	I am good at setting my own goals and completing them on time.	1	2	3	4	5
5	I can do well in a science class.	1	2	3	4	5

Energy

6	I know a lot about energy	1	2	3	4	5
7	The study of energy relates to my life.	1	2	3	4	5
8	Learning about energy is important	1	2	3	4	5
9	Learning about energy can be interesting	1	2	3	4	5

Energy Conservation

10	I use a lot more energy than I really need.	1	2	3	4	5
11	I would be willing to make changes to conserve energy	1	2	3	4	5
12	People should conserve energy/Conserving energy is important.	1	2	3	4	5
13	There are lots of ways to save energy	1	2	3	4	5
14	Conserving energy takes a lot of effort	1	2	3	4	5

Energy (II)

15	Fossil fuels are an irreplaceable and essential piece of our country's economy	1	2	3	4	5
16	We will never run out of energy	1	2	3	4	5
17	It is best to use a mixture of energy sources	1	2	3	4	5
18	I am [partly] responsible for nuclear waste	1	2	3	4	5

Learning and Application

19	I will probably remember what I learn in the energy unit.	1	2	3	4	5
20	I will probably use what I learn in the energy unit in my real life.	1	2	3	4	5

Post-Unit Survey

Name: _____
Date: _____ Hour: _____

For each statement on this survey, select the number that best represents your thoughts. A "1" means "strongly disagree" or "not at all" and "5" means "strongly agree" or "yes, always." Please answer HONESTLY. I want to know what you think and know. For the last few questions, please write in your answer with as much detail as you like.

strongly disagree <--> strongly agree

Learning/How to Learn

1	I learn best when "on my own" instead of being "taught" by someone else.	1	2	3	4	5
2	Students should be able to choose how they learn	1	2	3	4	5
3	It is easier to learn when you are given a lot of choices.	1	2	3	4	5
4	I am good at setting my own goals and completing them on time.	1	2	3	4	5
5	I can do well in a science class.	1	2	3	4	5

Energy

6	I know a lot about energy	1	2	3	4	5
7	The study of energy relates to my life.	1	2	3	4	5
8	Learning about energy is important	1	2	3	4	5
9	Learning about energy can be interesting	1	2	3	4	5

Energy Conservation

10	I use a lot more energy than I really need.	1	2	3	4	5
11	I would be willing to make changes to conserve energy	1	2	3	4	5
12	People should conserve energy/Conserving energy is important.	1	2	3	4	5
13	There are lots of ways to save energy	1	2	3	4	5
14	Conserving energy takes a lot of effort	1	2	3	4	5

Energy (II)

15	Fossil fuels are an irreplaceable and essential piece of our country's economy	1	2	3	4	5
16	We will never run out of energy	1	2	3	4	5
17	It is best to use a mixture of energy sources	1	2	3	4	5
18	I am [partly] responsible for nuclear waste	1	2	3	4	5

Learning and Application

19	I will probably remember what I learned in the energy unit.	1	2	3	4	5
20	I will probably use what I learned in the energy unit in my real life.	1	2	3	4	5

Layered Curriculum

21	I liked doing layered curriculum	1	2	3	4	5
22	I liked doing layered curriculum more than regular curriculum	1	2	3	4	5
23	I felt layered curriculum made me learn information better than they way classes are usually taught.	1	2	3	4	5
24	I feel like I know more about energy than I did at the beginning of this unit.	1	2	3	4	5

PLEASE TURN PAPER OVER FOR MORE ON BACK

Post-Unit Survey

Name: _____
Date: _____ Hour: _____

25. The best thing about layered curriculum was...
26. The worst thing about layered curriculum was ...
27. My favorite part of the energy unit was...
28. My least favorite part of the energy unit was...
29. I learned the most in this unit from...
30. Oral defenses were...
31. I feel more confident about what I know about energy than I did at the beginning of the unit. 1 2 3 4 5

APPENDIX D.6

Post Unit Self-Evaluation Questions

Students were asked to answer the following questions at the conclusion of the unit.

1. My overall motivation to do well in any aspect of this class is _____ out of 10.
2. In this unit, I gave about _____% of my best effort because ...
3. If I were getting a grade based on how much I tried and attempted to do well in this unit, my honest grade would be a _____.
4. I think I deserve this grade because...
5. Other comments about layered curriculum?

Name: _____ Date: _____ Counselor: _____

Teacher name: _____ Class: _____ Hour: _____

TRUE COLORS: Describe Yourself with Word Clusters

Below are five rows of word clusters. Score the clusters by going across, left to right, in rows. Score the word clusters in each row using a "4" for the groups MOST like you and continue with "3" for the next most like you, "2" for the next group and "1" for the LEAST like you. In each row, you should have a 1, a 2, a 3 and a 4.

Active Variety Sorts	☐	Organized Plan Neat	☐	Nice Helpful Friends	☐	Learning Science Privacy	☐
Fun Action Contests	☐	Clean On-time Honest	☐	Caring People Feelings	☐	Curious Ideas Questions	☐
Playful Quick Adventurous	☐	Helpful Trustworthy Dependable	☐	Kind Understanding Giving	☐	Independent Exploring Doing Well	☐
Busy Free Winning	☐	Follow Rules Useful Save Money	☐	Sharing Getting Along Animals	☐	Thinking Solving Problems Challenge	☐
Exciting Lively Hands-On	☐	Pride Tradition Do Things Right	☐	Nature Easy Going Happy Endings	☐	Books Math Making Sense	☐
TOTAL ORANGE	☐	TOTAL GOLD	☐	TOTAL BLUE	☐	TOTAL GREEN	☐

When you complete all five rows, add up each column of numbers to reveal your True Colors Spectrum. Your highest score indicates your Brightest Color, and the lowest scores represents the Color least like you.

APPENDIX D.8

True Colors Survey Background Information and Results

The True Colors Survey incorporates images, phrases, and a short set of questions, the results of which give an estimate of how “green,” “gold,” “orange,” or “blue” a student is relative to the other colors. A characteristic of gold personalities is that they tend to enjoy order. Green asks questions and enjoys being right. Blue is the peacemaker or social butterfly. Orange is adventurous. Each student has a little of each of these qualities, but some are more predominant than others.

Table 11: Compiled Results of True Colors Survey

Ranked Order of Colors in Study Participants (combined point sum)			
BLUE	ORANGE	GOLD	GREEN
238	213	182	167

Ranked Order of Colors in Study Participants (number of students with this color preferred)			
BLUE	ORANGE	GOLD	GREEN
7	6	3	2

These True Colors results are close to typical for a high school population. Usually orange is the most common personality class for adolescents, with blue being second. The variation in this selection is not large and the small sample size may have affected the results.

Multiple Intelligence Inventory Survey

Name: _____

Date: _____ Hour: _____

I. Place a one (1) next to each item below that describes you well.

Section 1 _____ I enjoy categorizing things by common traits _____ Ecological issues are important to me _____ Hiking and camping are enjoyable to me _____ I enjoy working in a garden _____ I believe preserving our National Parks is important _____ Putting things in hierarchies makes sense _____ Animals are important in my life _____ My home has a recycling system in place _____ I enjoy studying biology, botany, or zoology _____ I spend a great deal of time outdoors _____ TOTAL for Section 1	Section 2 _____ I easily pick up on patterns _____ I focus in on noise and sounds _____ Moving to a beat is easy for me _____ I've always been interested in playing an instrument _____ The cadence of poetry intrigues me _____ I remember things by putting them in a rhyme _____ Concentration is difficult while listening to a radio or television _____ I enjoy many kinds of music _____ Musicals are more interesting than plays _____ Remembering song lyrics is easy for me _____ TOTAL for Section 2
Section 3 _____ I keep my things neat and orderly _____ Step-by-step directions are a big help _____ Solving problems comes easily to me _____ I get easily frustrated with disorganized people _____ I can complete calculations quickly in my head _____ Puzzles requiring reasoning are fun _____ I can't begin an assignment until all my questions are answered _____ Structure helps me be successful _____ I find working on a computer spreadsheet or database rewarding _____ Things have to make sense to me or I am dissatisfied _____ TOTAL for Section 3	Section 4 _____ It is important to see my role in the "big picture" of things _____ I enjoy discussing questions about life _____ Religion is important to me _____ I enjoy viewing art masterpieces _____ Relaxation and meditation exercises are rewarding _____ I like visiting breathtaking sites in nature _____ I enjoy reading ancient and modern philosophers _____ Learning new things is easier when I understand their value _____ I wonder if there are other forms of intelligent life in the universe _____ Studying history and ancient culture helps give me perspective _____ TOTAL for Section 4
Section 5 _____ I learn best interacting with others _____ The more the merrier _____ Study groups are very productive for me _____ I enjoy chat rooms _____ Participating in politics is important _____ Television and radio talk shows are enjoyable _____ I am a "team player" _____ I dislike working alone _____ Clubs and extracurricular activities are fun _____ I pay attention to social issues and causes _____ TOTAL for Section 5	Section 6 _____ I enjoy making things with my hands _____ Sitting still for long periods of time is difficult for me _____ I enjoy outdoor games and sports _____ I value non-verbal communication such as sign language _____ A fit body is important for a fit mind _____ Arts and crafts are enjoyable pastimes _____ Expression through dance is beautiful _____ I like working with tools _____ I live an active lifestyle _____ I learn by doing _____ TOTAL for Section 6

Multiple Intelligence Inventory Survey

Name: _____

Date: _____ Hour: _____

Section 7

- _____ I enjoy reading all kinds of materials
- _____ Taking notes helps me remember and understand
- _____ I faithfully contact friends through letters and/or e-mail
- _____ It is easy for me to explain my ideas to others
- _____ I keep a journal
- _____ Word puzzles like crosswords and jumbles are fun
- _____ I write for pleasure
- _____ I enjoy playing with words like puns, anagrams and spoonerisms
- _____ Foreign languages interest me
- _____ Debates and public speaking are activities I like to participate in

_____ **TOTAL for Section 7**

Section 8

- _____ I am keenly aware of my moral beliefs
- _____ I learn best when I have an emotional attachment to the subject
- _____ Fairness is important to me
- _____ My attitude effects how I learn
- _____ Social justice issues concern me
- _____ Working alone can be just as productive as working in a group
- _____ I need to know why I should do something before I agree to do it
- _____ When I believe in something I will give 100% effort to it
- _____ I like to be involved in causes that help others
- _____ I am willing to protest or sign a petition to right a wrong

_____ **TOTAL for Section 8**

Section 9

- _____ I can imagine ideas in my mind
- _____ Rearranging a room is fun for me
- _____ I enjoy creating art using varied media
- _____ I remember well using graphic organizers
- _____ Performance art can be very gratifying
- _____ Spreadsheets are great for making charts, graphs and tables
- _____ Three dimensional puzzles bring me much enjoyment
- _____ Music videos are very stimulating
- _____ I can recall things in mental pictures
- _____ I am good at reading maps and blueprints

_____ **TOTAL for Section 9**

Multiple Intelligence Inventory Survey

Name: _____

Date: _____ Hour: _____

Multiple Intelligence Inventory Tally

II. Total up your score for each section of the survey.

Section	Section Total	Multiply	Score
1		X 10	
2		X 10	
3		X 10	
4		X 10	
5		X 10	
6		X 10	
7		X 10	
8		X 10	
9		X 10	

III. Make a histogram. (Shade in the boxes below to show your score for each category.)

<i>Your score in each category</i>	100									
	90									
	80									
	70									
	60									
	50									
	40									
	30									
	20									
	10									
		1	2	3	4	5	6	7	8	9
<i>Categories representing your individual strengths and areas of interest(see below)</i>										

Section 1 – This reflects your **Naturalist** strength

Section 2 – This suggests your **Musical** strength

Section 3 – This indicates your **Logical** strength

Section 4 – This illustrates your **Existential** strength

Section 5 – This shows your **Interpersonal** strength

Section 6 – This tells your **Kinesthetic** strength

Section 7 – This indicates your **Verbal** strength

Section 8 – This tells your **Intrapersonal** strength

Section 9 – This suggests your **Visual** strength

My top three greatest strengths are:

1. _____
2. _____
3. _____

Multiple Intelligence Inventory Survey

Name: _____

Date: _____ Hour: _____

Multiple Intelligence Inventory Tally

IV. Key to Howard Gardner's Multiple Intelligences

Circle your top three strengths.

Section 1 - This reflects your Naturalist strength • Likes to observe, care for and interact with the natural world; plants and animals • Is good at making and justifying differences, and comfortable using a symbolic system. • Learns best by: sorting, classifying, or distinguishing among the differences between things.	Section 2 - This suggests your Musical strength • Likes to: sing, hum tunes, listen to music, play an instrument and respond to music. • Is good at: picking up sounds, remembering melodies, noticing pitches / rhythms and keeping time. • Learns best by: rhythm, melody, and music
Section 3 - This indicates your Logical strength • Likes to: do experiments, figure things out, work with numbers, ask questions and explore patterns and relationships. • Is good at: math, reasoning, logic, and problem solving. • Learns best by: categorizing, classifying and working with abstract patterns/relationships.	Section 4 - This illustrates your Existential strength • Likes to: consider the infinite and the infinitesimal; able to see the "big picture." • Is good at: considering or contemplating "ultimate" issues, but no stipulation on finding the ultimate truth. • Learns best by: asking and considering BIG questions. Often can come up with broad insights to a given problem.
Section 5 - This shows your Interpersonal strength • Likes to: have lots of friends, talk to people and join groups. • Is good at: understanding people, leading others, organizing, communicating, manipulating and mediating conflicts. • Learns best by: sharing comparing, relating, cooperating and interviewing.	Section 6 - This tells your Kinesthetic strength • Likes to: move around, touch and talk and use body language. • Is good at: physical activities (sports/dance/acting) and crafts. • Learns best by: touching, moving, interacting with spaces and processing knowledge through bodily sensation.
Section 7 - This indicates your Verbal strength • Likes to: read, write, and tell stories • Is good at: memorizing names, places, dates and trivia. • Learns best by: saying, hearing and seeing words	Section 8 - This tells your Intrapersonal strength • Likes to: work alone and pursue own interests. • Is good at: understanding self, focusing inward on feelings/dreams, following instincts, pursuing interests/goals and being original. • Learns best by: working alone, individual projects, self-paced instruction and having own space.
Section 9 - This suggests your Visual strength • Likes to: draw, build design and create things, daydream, look at pictures/slides, watch movies and play with machines. • Is good at: imagining things, sensing changes, mazes/puzzles and reading maps and charts. • Learns best by: visualizing, dreaming, using the mind's eye and working with color/pictures.	

APPENDIX D.10

Multiple Intelligence Class Data

Table 12: Compiled Results of Multiple Intelligence Survey

Ranked Order of Intelligences in Study Participants (combined point sum)								
Intra-personal	Musical	Existential	Inter-personal	Kinesthetic	Verbal	Visual	Logical	Naturalist
101	89	82	79	78	68	65	61	34

Ranked Order of Intelligences in Study Participants (number of students with intelligence ranked in top two, tie scores included)								
Intra-personal	Musical	Existential	Inter-personal	Kinesthetic	Verbal	Visual	Logical	Naturalist
10	4	6	5	4	3	2	3	0

Naturalist was not in the top two intelligences of any of my students. This was not surprising as my students come from an urban background and in my experience I have not met many naturalists in the setting of this school. That logical came in at a low ranking was also not surprising given its typical representation in a high school population.

I was mildly surprised that intrapersonal intelligence was more prevalent than interpersonal. Generally high school students utilize the interpersonal to a great extent. This was the first time I had administered this particular test to a group of students, so there may be some unknown bias in it that skewed results. However, it is also possible that the students in my test sample were indeed stronger in intrapersonal intelligence.

ENERGY TEST **DO NOT WRITE ON THIS TEST!!!**

Follow all directions and write answers on a separate sheet. For the multiple choice, select the best answer.

ENERGY AND OUR ENERGY SOURCES

1. **Draw** how we get electrical energy from coal. Include all the energy transfers from as far back as you can go.
 - Clearly label the key components of your diagram.
 - Clearly label all the energy forms involved in this process.
 2. What are the two main components of a **generator**, and how do they interact?
 3. Use words to describe how geothermal energy works.
 4. Name one energy source that uses a turbine and one energy source that does not use a turbine. Indicate which is which.
-
5. Which of these do NOT involve converting chemical potential energy into heat energy?
 - a. Nuclear power
 - b. Biomass
 - c. Fossil Fuels
 - d. Both A and C
 6. Which of these do NOT involve kinetic/mechanical energy?
 - a. Fossil fuels
 - b. Solar cells
 - c. Wind
 - d. Nuclear fission
 7. Which of these does not convert one kind of energy to another kind of energy?
 - a. Green plants
 - b. Generators
 - c. Combustion (burning)
 - d. Insulators
 8. What sources do not give off CO₂ gas and do not depend on location?
 - a. Solar cells
 - b. Hydrogen fuel cells
 - c. Wind
 - d. Geothermal

ENERGY TEST

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9. Which of these sources relies on highly heated water?
 - a. Geothermal
 - b. Solar cells
 - c. Hydrogen fuel cells
 - d. Hydroelectric power
10. Which of these answers contains a FALSE statement?
 - a. A negative of geothermal is that it can only be used in certain places, but a negative of nuclear power is that it produces a lot of air pollution.
 - b. A negative of wind power is that it takes up a lot of space, but a negative of fossil fuels is that they produce a lot of carbon dioxide.
 - c. A negative of geothermal is that the heat of hot spots can be used up, but a negative of solar power is that it cannot be used everywhere.
 - d. A negative of tidal energy is that it can damage coastal ecosystems, and a negative of hydroelectric power is that building dams can damage river ecosystems.
11. Acid rain is caused by
 - a. Sulfur compounds release from burning coal and mixing with water.
 - b. Heat from light bulbs creating toxic gases.
 - c. The large number of nuclear power plants.
 - d. Only carbon dioxide.
12. One main reason for the worldwide slowdown in nuclear plant construction is that
 - a. We have already run out of nuclear fuel
 - b. Fossil fuels produce less toxic fumes than nuclear plants
 - c. Nuclear energy is extremely expensive
 - d. We have begun to use solar energy as our primary energy source
13. Converting solar energy into electrical energy
 - a. Can meet the energy needs of most places cheaply and efficiently
 - b. Has much potential but also limitations
 - c. Is a nonrenewable energy source
 - d. Produces water as a byproduct
14. Which is an example of a direct use of fossil fuels?
 - a. An oil-fired furnace
 - b. A nuclear reactor
 - c. A wood-burning stove
 - d. An electric generator

ENERGY TEST

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Follow all directions and write answers on a separate sheet. For the multiple choice, select the best answer.

15. Ninety percent (90%) of our energy needs are currently filled by _____.
16. What specific event are these 5 statements referring to?
- The site will be radioactive for the next 25,000 years.
 - People are not supposed to live near the site.
 - Radioactivity spread through the air to other countries.
 - The disaster happened in 1986.
 - There is a higher incidence of cancer in that area than unexposed areas.

KEEP GOING! YOU'RE DOING GREAT 😊!

State whether these are renewable or nonrenewable sources of energy by writing "RENEWABLE" or "NONRENEWABLE."

17. Solar power
18. Wind power
19. Fossil fuels
20. Nuclear power
21. Biomass
22. Hydroelectricity

For the following questions, state whether the energy source can trace its energy back to the sun. Answer YES if it can or NO if it can't.

23. Biomass
24. Biofuel
25. Fossil Fuels
26. Wind power

ENERGY TEST **DO NOT WRITE ON THIS TEST!!!**

Follow all directions and write answers on a separate sheet. For the multiple choice, select the best answer.

ENERGY CONSERVATION

27. Which of these is the least effective insulator?
- Styrofoam cup
 - Pink insulation found in attics
 - Glass windows
 - A thermos
28. Which of these is a way to conserve energy in your house?
- Not running the water while you brush your teeth
 - Using smaller amounts of insulation
 - Lowering the thermostat when you are sleeping or gone
 - Installing windows on the north side of the house to let in sun
29. Define “renewable resource” and “nonrenewable resource” and give an example of each.
30. What are two reasons to conserve energy?
31. List 5 things you can do to conserve energy in your house right now.

YOUR ENERGY

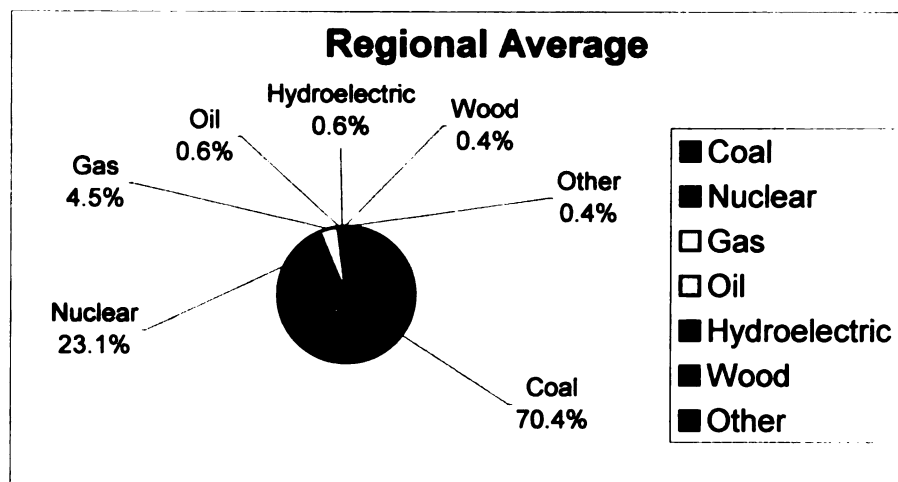
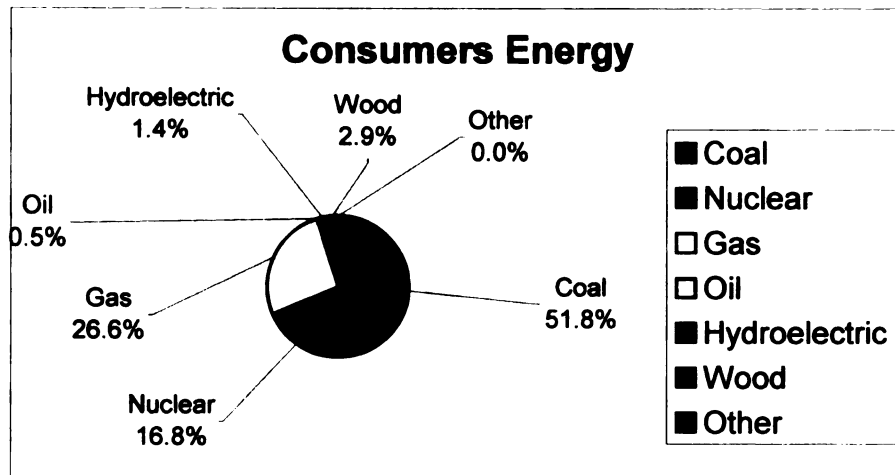
32. Are you responsible for nuclear waste? Explain fully. (2 pts)
33. If Southfield, Michigan were to begin using nuclear energy or solar power, which do you think we should choose? Explain your opinion and provide 3 supporting pieces of evidence. Use complete sentences. (4 pts)

Look at the data table and the two graphs, then answer the questions that follow.

Emissions or Waste (in pounds per megawatt-hour)	Consumer's Energy Total Production	Regional Average (Fuel mix purchased from MI, IL, I, OH, WI. This makes up approximately 3% of Consumers Energy Total)
Sulfur dioxide	8.79	18.70
Carbon dioxide	2211.79	2094.50
Oxides of nitrogen (NOx)	3.09	7.0
High-level nuclear waste	.0068	.0074

ENERGY TEST **DO NOT WRITE ON THIS TEST!!!**

Follow all directions and write answers on a separate sheet. For the multiple choice, select the best answer.



34. Who uses more coal, Consumers Energy's total production or the Regional Average?
35. Who produces more sulfur dioxide and nitrogen dioxide, Consumers or the region?
36. a) Who is the biggest source of sulfur dioxide and nitrogen dioxides, Consumers or the region?
 b) Use the data and your knowledge to state why is this so. Explain fully in complete sentences. (2 pts)

ENERGY TEST

DO NOT WRITE ON THIS TEST!!!

Follow all directions and write answers on a separate sheet. For the multiple choice, select the best answer.

MISCELLANEOUS

37. What are two drawbacks of hydroelectric power? (2 pts)
38. What is one good thing and one bad thing about wind power? (2 pts)
39. Why is acid rain an international problem? Explain fully using complete sentences. (2 pts)
40. What are two reasons you – I mean you personally – should try to reduce your energy use? (2 pts)

END OF TEST ☺

.....

NOTE: The 2004-2005 version of this test included a short newspaper article and the following questions for students to respond to using the article.

Read the article “Expert says fuel cells will benefit nation.” Then answer the following questions.

41. In theory, how long will a fuel cell work?
42. What values would make a business buy a fuel cell? Explain.
43. If more people bought hydrogen fuel cells, what would probably happen to the cost of the fuel cells?
44. Why would the Governor of Michigan be interested in fuel cell technology?

APPENDIX D.12

Comparison of 2004-2005 and 2005-2006 Data*

* The 2004-2005 Energy Unit was taught using a traditional format. The 2005-2006 Energy Unit was taught using a layered curriculum format.

Table 14: Energy Unit Test Results Compared Over Two Years

	2004-2005 <i>n = 35</i>	2005-2006 <i>n = 21</i>	2005-2006* <i>n = 17</i>
Average	58%	54%	56%
Points possible in rubric	64	72	72
Comments	The tests given in the 2004-2005 and 2005-2006 school years were identical with two exceptions: 1) The 2004-2005 test included one short required reading section and one extra credit reading section 2) The rubric for the written response was more elaborate and worth more points in 2005-2006. <i>Extra credit is not included in this percentage.</i>		

Table 15: Post-Test Results Compared Over Two Years

	2004-2005 <i>n = 16</i>	2005-2006 <i>n = 20</i>	2005-2006* <i>n = 16</i>
Question 1	66%	65%	48%
Question 2	50%	71%	55%
Question 3	48%	62%	53%
Question 4	68%	53%	47%
Question 5	<i>not included</i>	73%	67%
Question 6	39%	73%	62%
Question 7	72%	88%	97%
Total Average Percent	58%	69%	62%

* includes only scores of study subjects

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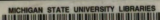
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