TEACHING CHEMISTRY IN CONTEXT:

THE EFFECT ON STUDENT LEARNING AND ATTITUDES

by

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ABSTRACT

In this investigation, chemistry content was taught in-context with real world examples in order to determine the effects of student learning and attitudes toward chemistry. Participants included one class of four high school students in an advanced chemistry course. The treatment included three in-context units including the topics of Gasoline, Biofuels, and Plastics. Student learning was assessed using Pre and Post-Knowledge Probes, Focused Listing, and Daily Diagnostic Learning Logs. Student attitude changes were assessed using surveys, interviews, and observations during small group discussions. Results indicated that student learning was positively impacted as all Post-test outcomes had an average increase of over 45%. Student interviews showed that attitudes were positively impacted as all students said they liked chemistry, and after the treatment, found enjoyment in knowing how the world works.

INTRODUCTION AND BACKGROUND

For the past six years I have taught various levels and subjects of science. These experiences ranged from teaching summer science camps for girls between the ages of five and fourteen to teaching labs and discussions for college-level general chemistry. I taught physics at a summer science camp, and finally I have spent the last three years teaching high school environmental science, chemistry, advanced chemistry, human anatomy/physiology, and physics. Throughout all these teaching experiences, I have had the opportunity to implement numerous teaching techniques and curriculums. However, the experience that most stands out in my mind, comes from teaching college labs and discussions with the Chemistry in Context curriculum (American Chemical Society, 2009).

The Chemistry in Context curriculum is an American Chemical Society publication that uses an issues-based approach to teaching science content. In this course, chemistry content was built into specific societal issues such as global warming, the hole in the ozone layer, nuclear radiation, and food. I was amazed at how my students became so involved in the subject and found numerous connections between their lives and the content I was teaching. I observed tremendous concept development and understanding as they were also able to apply the concepts they learned to numerous societal issues.

Through my own teacher reflection I have compared my teaching experience using issues-based instruction with traditional styles, and I am still fascinated at the student engagement and connections made in my Chemistry in Context experience. These observations led me to contemplate whether or not issues-based science instruction in

other age groups would demonstrate increased student engagement and understanding of science concepts as they had at the college level.

This project was implemented at Ogallala High School (OHS) in Ogallala, Nebraska. OHS is a public high school that serves a population of about 300 students in grades 9-12 (Ogallala Public School District, 2011). The treatment was completed on an advanced chemistry class, which encompasses an elective second year of general chemistry. The class consisted of four students, three female and one male. Of these students, three were seniors and one a junior. All of these students can be considered some of the top achievers in their cohort, both in and out of the classroom. Furthermore, each student wants to go into a science-related field, and they always come to class with an eagerness to learn.

Observations of an issues-based science curriculum at the college level led me to my primary focus question: What are the effects on student learning and attitudes when chemistry is taught in context? Specifically, I wanted to know:

1) How does teaching chemistry in context affect learning of content?

2) How does teaching chemistry in context affect depth of understanding of content?

3) How does teaching chemistry in context affect student attitudes of chemistry

CONCEPTUAL FRAMEWORK

Teaching science in context, also known as a *science-technology-society* (STS) approach, is a technique that involves using contexts and applications of science in order to develop science understanding (Bennett, Lubben, & Hogarth, 2006). Highly supported by the National Science Teachers Association, it is believed that teaching science in context can provide a rich and motivating perspective in which students can learn the principles of science and technology (NSTA, 2010).

When discussing the learning and teaching with an STS approach, it should be noted that all learning occurs in some form of context. In today's science class, this learning context has been set by national and state standards, much of which is often perceived to be abstract and irrelevant to students' everyday experiences (Rodrigues, 2006). Historically, science content, rather than application, has formed the basis of science curriculum (DeBoer, 2000). Within the confines of this conventional, content-based approach, teachers start by introducing the core concepts and are then encouraged to reinforce that core material with contexts and applications of their choice, but only to the extent that time is available (Stinner, 1994). Typically the focus is on the transmission of the concept from teacher to student, and the optional associated experiences or applications only apply at the end (Figure 1) (Beasley, n.d.).

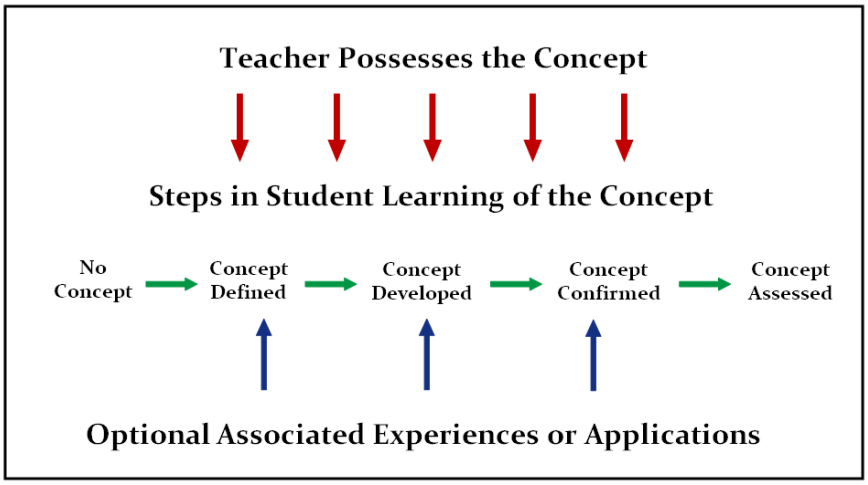


Figure 1. A model of concept development in a typical science classroom (Adapted from Beasley, n.d.).

Due to the abstract nature of science concepts, students often see science as disconnected from their lives. However, science has immense cultural significance, and science education should highlight the major landmarks and people in our understanding of the natural world (Irwin, 2000). Using science stories, thematic teaching, and popular science literature allows for a more humanistic view of science (Stinner, McMillan, Metz, Jilek, & Klassen, 2003). These resources allow the science concepts to be more within the scope of the student's comprehension level, as understanding how an event took place gives some insight into a field that the student is unlikely to have enough background knowledge to understand (Irwin, 2000).

In order to initiate a humanistic view of science and create easier understanding, a suggested approach to teaching is to begin with a well-developed context or application that pulls in students' interest and is connected to their experiences (Stinner, 1994). In general, this means starting with the application and using it to illustrate the science (Rodrigues, 2006). From this point forward, STS or context-based approaches will be defined as those where contexts and applications of science are used as the starting point

for the development of scientific ideas that emphasize links between science, technology and society (Bennet et al., 2006). This should not be confused with the broad term STEM that implies all education that involves the subjects of science, technology, engineering, and mathematics (STEM Education Coalition, 2011).

There are various illustrations of what an STS approach might look like in a classroom; however, a general outline can be given (Figure 2). First, the context is introduced and the students can then explore the subject and frame the problems within it. Next, students examine what they already know about the topic and determine what they need to find out. The instructor then guides the students through investigations, research, and experiments to gain additional knowledge. This learning eventually helps the students finalize their thoughts and conclusions on the context (Beasley, n.d.).

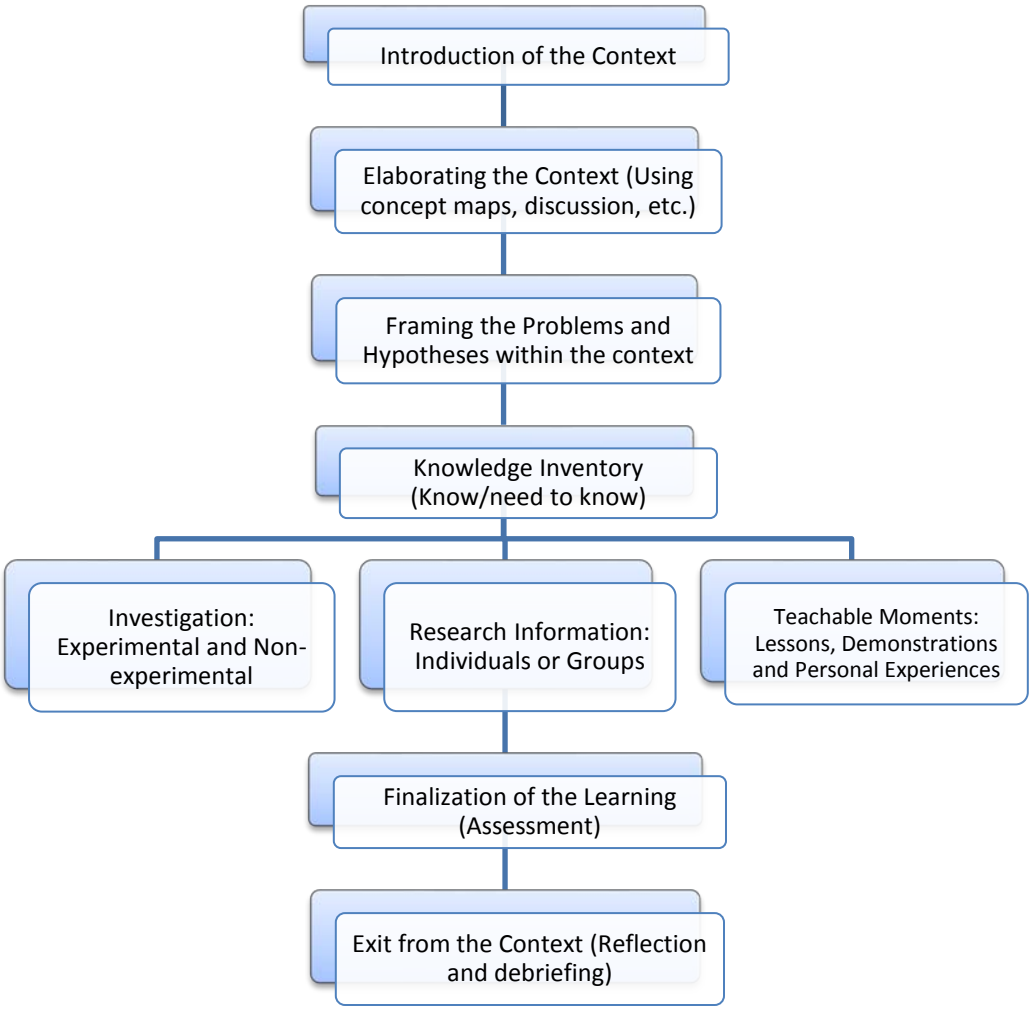


Figure 2. A model outline of a context-based unit (Adapted from Beasley, n.d.).

Teaching in context can be quite different from traditional, content-based approaches (Table 1). Content-based teaching tends to focus on specific content within disciplines and typically separates science content into small pieces. However, an STS approach is characterized mainly by broad integrative elements. STS methods also teach content in relation to the personal needs of students and make connections to important aspects of contemporary life (DeBoer, 2000 & Beasley, n.d.). In general, the context

allows science education to be a life enhancing process that contributes to the quality of students' lives, rather than just delivering facts and information (Phoenix, 2002).

Table 1
Comparison of emphasis within content-based and STS approaches (Adapted from Beasley, n.d.)

Content-Based Approach	STS approach
Emphasis on:	Emphasis on:
• Knowing scientific facts and information	• Understanding scientific concepts and developing abilities of inquiry
• Studying subject matter of disciplines	• Learning subject matter in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
• Separating science knowledge and science content	• Integrating all aspects of science content
• Covering many science topics	• Studying a few fundamental science concepts
• Implementing inquiry as a set of processes	• Implementing inquiry as instructional strategies, abilities, and ideas to be learned

The STS approach has been seen as somewhat controversial because social issues, and not disciplinary content, become the organizing themes of science teaching. The challenge is to find a balance between the science content and other important goals of science education. These goals include scientific literacy, understanding the nature of science (NOS), humanizing science concepts, and increasing motivation and understanding (DeBoer, 2000).

Scientific literacy is a term that describes the desired understanding of science on the part of the general public, what the public should know in order to live more

effectively with respect to the natural world (DeBoer, 2000). Health, climate change, bioethics, and energy are just a few personal and societal issues that require citizens to make informed decisions based on science and technology (NSTA, 2010). Therefore, teaching and learning science in context can help students establish links between science and their ideas on the issues affecting them (Rodrigues, 2006).

Teaching the nature of science can be integrated in many science topics. However, it can be difficult to get students to understand that scientific progress is not accidental. The growth of scientific knowledge is characterized by great imagination and creativity that help establish models and unifying principles (Irwin, 2000). One of the aims of teaching and learning science in context is to promote students to use science content in problem solving by establishing links with other stores of knowledge (Rodrigues, 2006). It also can show students that there are parts of science history where the power of the human mind has made amazing conjectures with very little information, and these ideas can lead to an incredible enhancement of scientific knowledge (Irwin, 2000).

Furthermore, the goal of increasing motivation and understanding can be affected by designing contexts which attract students' interests (Stinner, 1994). The most significant target of science teaching is for students to enjoy their experience of science, and the contexts used to develop scientific ideas can motivate students and change their feelings about the subject by helping them see the importance of what they are studying. If students are more interested and motivated by science experiences in class, this increased engagement might result in improved learning (Bennett et al, 2006). However,

in order to sustain understanding and application, contextual learning has to be part of the whole science course (Yip, 2006).

In order to accommodate student interests and local considerations, it is recommended that local school districts decide the topics to be presented in an STS approach (DeBoer, 2000). These areas of context can then be introduced through topical material or local events. Also, familiar themes can be used for starting points. An example would be a lesson that used scientific concepts involved in fabrics, textiles, and clothing, topics that are fairly familiar to the students (Rodriguez, 2006). This type of lesson has potential to be successful because concrete representations require fewer mental hurdles on the learner's part, and therefore, are easier to understand (Olson & Mokhtari, 2010).

There are numerous other ways to incorporate context-based curriculum into science teaching as well, and researchers have highlighted the benefits associated with these techniques (Table 2).

Table 2
Methods and benefits of techniques associated with teaching science in context (Adapted from Stinner, 1994 & Stinner et al, 2003)

Methods of incorporating STS ideas into the classroom	Potential Benefits
1. Vignettes	• Gives students the opportunity to connect concepts with their interests • Can inspire students to read more about science and scientists
2. Case studies and thematic narratives	• Connects concepts to one, unifying idea
3. Confrontations, dialogues, dramatizations	• Can incorporate historical or debated contexts into science content
4. Large Context Problems (LCPs)	• Creates a contextual setting that generates questions and problems that are more interesting to students

In teaching chemistry, Johnstone (1991) has proposed three levels of understanding that are expected from the student; the macroscopic, submicroscopic or particulate, and the symbolic levels (Table 3). Chemistry taught with a content approach typically emphasizes the symbolic level as mathematical aspects are heavily emphasized. However, while the student is able to accomplish the given process, they may not actually understand the significance. When chemistry is taught in-context, students' understanding of all the levels tends to improve as the context more easily integrates the three forms, and gives concrete examples to concepts that are traditionally very abstract (Ware, 2001).

Table 3
Levels of understanding chemistry (Adapted from Johnstone, 1991)

Level	Description
Macroscopic	Students understand the physical and chemical phenomena of chemistry.
Submicroscopic or Particulate	Students understand models of chemical behavior at the atomic and molecular levels.
Symbolic	Students understand symbols, formulas, and mathematical relationships used in describing chemical relationships.

Many scientific research studies have been conducted on STS teaching and abundant evidence has been collected on the technique's effectiveness. With all styles of teaching, learning and depth of understanding has to be evaluated. The *Web Alignment Tool* (Appendix A) can be used to evaluate both, as learning basic science content can be defined as lower level learning (Level 1 or 2), and evaluation and application of content can be considered higher level learning (Level 3 or 4) (Webb, 2006).

In an action research study done by Lin (1998), case studies were used to teach pre-service teachers how to teach chemistry using the history of science. The results showed that after the in-context lesson, the experimental group seemed to better understand creativity, scientific observations and the function of theories (Lin, 1998). The treatment group indicated that the changes were caused by the reading of case studies in history of science, and they were all able to use examples to support their beliefs in the post-treatment interviews.

Another study utilized historical content to teach about atoms for a class of 14 year olds, while another class was taught with traditional methods. The teacher researcher was disappointed to find there was no difference in understanding of the science content between the two groups but was still able to make a case for using historical examples in order to influence the learning of the nature of science. The fact that content knowledge was not weakened by the unorthodox teaching methods supported his suggestion of using historical contexts to teach science (Irwin, 2000).

In additional research, a lesson was observed that taught in-context by using a familiar theme to initiate dialogue amongst the students. It was found that simply using a relevant context does not necessarily result in a lesson being taught in-context. The students were engaged with the topic, but the assigned tasks were not meaningful. Therefore, the learning may not have been enhanced by the contextual teaching effort (Rodrigues, 2006). This could be a reason why instructors often use an STS approach at the beginning of a course and then revert back to traditional teaching. This does not allow for sustained learning in the contextual framework, and eliminates the benefits that can be associated with teaching in-context (Yip, 2006).

Finally, a systematic review done by Bennett et al (2006) assembled multiple studies to compare their findings. It was determined that context-based/STS approaches resulted in improved attitudes of science more than conventional approaches, and there was mixed evidence that the contextual approach influenced subject and career choices. Teaching in context also resulted in more positive attitudes of science in both girls and boys. Furthermore, just over half of the studies demonstrated that the understanding of scientific ideas was comparable to that of conventional approaches. One case even suggested that students had less frequent misunderstandings when taught with STS methods.

The in-context teaching approach uses a variety of tools to bring science concepts to life for students. Learners are able to personally connect with a topic and then work through science concepts to understand the issue. By presenting science in a way that is meaningful to the student, it allows for a more humanistic view of science and also has the ability to increase scientific literacy and learning of the nature of science.

METHODOLOGY

The purpose of this study was to investigate the effect on student learning and attitudes when chemistry is taught in-context. The treatment group of this study included an advanced chemistry class at the high school level composed of four students. Identification numbers, one through four, were assigned to each throughout the time period in order for data analysis of individual students. Three units were taught using a real world theme to introduce the relevant content (Table 4). As the instructor, I provided

guidance to students as they uncovered pre-existing knowledge, developed new questions pertaining to the theme, and I also created links to key science concepts that composed the learning objectives of the unit. The students participated in teacher and student led discussions, labs, and skill building activities that were based on the beginning theme; however, chemistry content was still at the core of the learning. Before data collection, the students had relatively little exposure to applying chemistry concepts to real world applications, so teaching chemistry in-context was a significant change from normal classroom instruction. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained. Principal consent was given for all instruments in the treatment to be given (Appendix B).

Table 4
Unit themes and associated chemistry content

Unit	Theme	Associated Chemistry Content
1	Petroleum and Gasoline	• Alkane, alkene and alkyne structures, naming and properties • Isomers • Distillation • Complete and incomplete combustion
2	Biofuels	• Organic functional groups • Isomers • Organic reactions • Energy content
3	Plastics	• Polymers • Addition polymerization • Condensation polymerization • Chemical additives • Chemical recycling

The timeline for the three units was spread out over three months; with lessons being taught in 55-minute classes, Monday through Friday (Appendix C). A general flow

of events during the units included theme identification, multiple exploratory labs and activities with discussions, teacher-led lectures and practice sessions, and final evaluation of learning (Table 5). During the unit instruction, corresponding data collections were taken at specific times during the lessons.

Table 5
STS unit activity general outline and corresponding data collection

Class Period	Lesson	Data Collection
Pre-Instruction	No instruction given yet	Background Knowledge probe
Class #1, 2	• STS topic is introduced/problem is identified • Small group discussions	(B): Focused Listing (D): Teacher Journal/Field Notes (A): Diagnostic Learning Log
#3,4	• Laboratory/Activity Exploration	(B): Focused listing (D): Teacher Journal/Field notes (A): Diagnostic learning Log
#5,6	• Analysis of Problem/Data • Small group discussions	(B): Focused Listing (D): Teacher Journal/Field Notes (A): Diagnostic Learning Log
#7,8	• Laboratory/Activity Exploration	(B): Focused listing (D): Teacher Journal/Field notes (A): Diagnostic learning Log
#9, 10	• Analysis of problem/Data • Small group discussions • Draw conclusions	(B): Focused Listing (D): Teacher Journal/Field Notes (A): Diagnostic Learning Log Background Knowledge probe

Note. Before the lesson [B], during the lesson [D], and at the end of the daily lesson [A]

Before the in-context unit was introduced, the Colorado Learning Attitudes about Science Survey (2006), also known as the CLASS-Chem survey, was given to all students to determine student attitudes of chemistry (Appendix D). This survey, used with permission from the Physics Education Technology Project, included Likert scale questions, ranging from strongly agree (5) to strongly disagree (1). Students completed their survey via the internet, and the students completed the same survey at the end of the

study. The survey questions were grouped into different categories based on their content and the responses were analyzed as favorable, or answering more like an expert chemist, and unfavorable, or answering similar to a novice chemist (Table 6). Mean response variations from the collected data sets were recorded and the shift for individual categories as well as the overall trend was analyzed.

Table 6
CLASS-Chem survey categories and descriptions

CLASS-Chem survey categories	Description
Personal interest	• Do students feel a personal interest in/connection to chemistry
Real world connection	• Seeing the connection between chemistry and the real world
Problem Solving (PS) o General o Confidence o Sophistication	• General – Student perceptions of using math, memorizing, and people's ability to understand chemistry • Confidence – Students thoughts on their ability to solve chemistry problems • Sophistication - understanding of the chemistry behind assigned chemistry problems
Sense making/effort	• Student perception of whether it is worthwhile to put out the effort to make sense of problems
Conceptual connections	• Understanding that chemistry is coherent, and about sense-making, drawing connections, and reasoning not memorizing
Conceptual learning	• Understanding and applying a conceptual approach and reasoning in problem solving, not memorizing or following problem solving formulas
Atomic-molecular perspectives	• Understanding that atomic and molecular arrangement is important to chemical activity

Individual Interviews of each student were conducted before and after the treatment (Appendix E). These interviews focused on student attitudes of the subject of chemistry and attitudes on learning chemistry. They also acquired answers with more depth than the written surveys and were used to supplement the data received in the

CLASS-Chem surveys and teacher observations. Interview responses were furthermore analyzed and coded for similarities.

A Background Knowledge Probe of the science content within each unit was given before any instruction (Appendices F, G, and H) (Angelo & Cross, 1993). The Probe was written with questions that tested varying levels of knowledge determined by the *Web Alignment Tool*, and contained questions that involved level one, two, and three depths of knowledge (Table 7). Each question was assigned a point value based on typical classroom grading procedures. The Probe was evaluated by finding an overall score as well as the total points for each level of question. Mean scores for each Knowledge Probe were found based on point values assigned to each question. Student scores were recorded and also evaluated to find the class average. After each unit, the same Knowledge Probe was given as a post-test. Overall score variations for each student were examined from these results, as well as the percent change in score from pre-unit to post-unit instruction and reported using the student identification number. These changes were considered for both individual students and class averages. Furthermore, Probe responses were coded for similarities in student ideas both before and after the unit, as well as common misconceptions that were evident in the student's final conceptual understanding. Finally, the change in the level of understanding of each student was evaluated based on the performance on each level of question.

Table 7
Depth of knowledge verbs on Pre and Post-Knowledge Probes

	Comparable verbs used to determine depth of knowledge tested		
	Level 1	Level 2	Level 3
Gasoline Unit	• Circle/Identify • Write the name	• Draw an isomer/Relate multiple structures • Write the balanced equation/Distinguish between reaction types • Relate the reaction to quantities/Calculate	• Draw conclusions • Explain phenomenon in terms of concepts
Biofuels Unit	• Draw	• Draw a structure and modify it to show an isomer • Show	• Construct models and draw conclusions
Plastics Unit	• Tell • Name	• Write the balanced equation • Explain/Compare • Describe/Compare • Use context clues	• Develop a logical argument

At the beginning of each class, a *Focused Listing* classroom assessment was completed (Angelo & Cross, 1993). Students were given a word from the unit content and then given one minute to list words and phrases they associated with the prompt. This Focused Listing was repeated at the beginning of every class for the rest of the individual unit using the same word or phrase. For the first unit the given word was *gasoline*. *Biofuels* was the prompt for the second unit, and *plastics* the word for the final unit. The data collected was compared to a master list of words that I developed and examined for quantity, the number of words matching the master list, and quality, the specific words that matched the master list (Appendix I). A higher frequency of words matching the master list was interpreted as an indication of higher level thinking, as associating key terminology with a topic is suggestive of increased levels of learning. The responses were also examined for relevancy to the unit content and for ideas developed from class instruction versus those coming from the student's personal

connections. This ongoing data collection provided additional information in interpreting how the students' ideas and depth of knowledge were developing throughout the unit.

A Daily Diagnostic Learning Log was completed by each student at the end of class (Angelo & Cross, 1993). These responses consisted of answers to a Daily Diagnostic Learning Log entry form (Appendix J). This information was examined for student identification of learning objectives and problems the students were having in their own understanding.

Also, during the unit I kept a journal of field notes to record observations of student learning, behavior, peer interactions, and student attitudes. This and the previous data sources described above are summarized in Table 8. Together they provide triangulated data for my investigation of learning and attitudes of chemistry associated with an STS instructional approach.

Table 8
Data collection strategies matrix

Data Collection Strategy	Pre In-Context Unit	During In-Context Unit	Post In-Context Unit
#1	CLASS-Chem Survey	Daily Diagnostic learning logs	CLASS-Chem Survey
#2	Individual Student Interviews	Teacher Journal/Field notes	Individual Interviews
#3	Background Knowledge Probe	Focused Listing	Background Knowledge probe
#4	Focused Listing		Focused Listing

DATA AND ANALYSIS

Pre and Post-Knowledge Probe scores were compared to examine student learning throughout each in-context unit (*N*=4). Pre-test scores indicated students had very little knowledge of the content prior to instruction. Among the Gasoline pretests, there were only two students who answered any of the questions correctly; and in the Biofuels unit, only one pretest had any correct responses. The Plastics unit Pre-Knowledge Probes had no correct responses. From the Teacher Journal it was observed that the students laughed as they read the questions, and remarks were made such as, “Well, this makes me feel dumb,” and “You might as well have not even wasted this paper.”

There were large increases in scores from the Pre to Post-Knowledge Probe. In the Gasoline unit there was an average score increase of 46%, an average score increase of 50% in the Biofuels unit, and 66% in the Plastics unit. Students even commented after the Post-Knowledge Probes that they knew more than they thought, and in particular, Student 3, commented, “It doesn't seem that we learn a lot, but when I go to take my test, I find out that I learned a lot more than I thought I did.”

In reviewing Pre and Post-Knowledge Probe scores, there was a noticeable difference in the average post-test scores for Student 4 compared to others in the class (Figure 3). Students 1, 2, and 3 consistently scored at least 15% higher. The largest difference was on the Gasoline unit post-test where Student 2 scored almost 75% higher than Student 4.

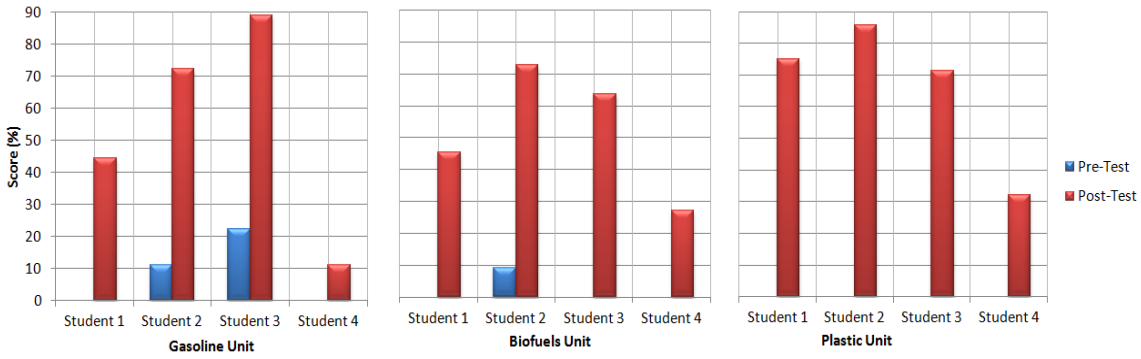


Figure 3. Pre and Post-Knowledge Probe scores (%) for all students, (*N*=4).

Daily Focused Listings were used as another indicator of student learning. Of all the words and phrases listed by the students, an average of 88% of responses in the Gasoline unit were found to be relevant to the topic, and 98% of responses were found to be relevant in both the Biofuels and Plastics unit. When compared to a master list of words and phrases that I felt were conceptually important to the theme being studied, students were able to match a minimum average of 35% of them on their own lists (Figure 4). In the Gasoline unit, the highest percentage of words matched by any student was 41%, in the Biofuels unit the highest was 53%, and in the Plastics unit it was 54%. The lowest percentage of words matched by any student was 32% in the Gasoline unit, 37% in the Biofuels unit, and 30% in the Plastics unit.

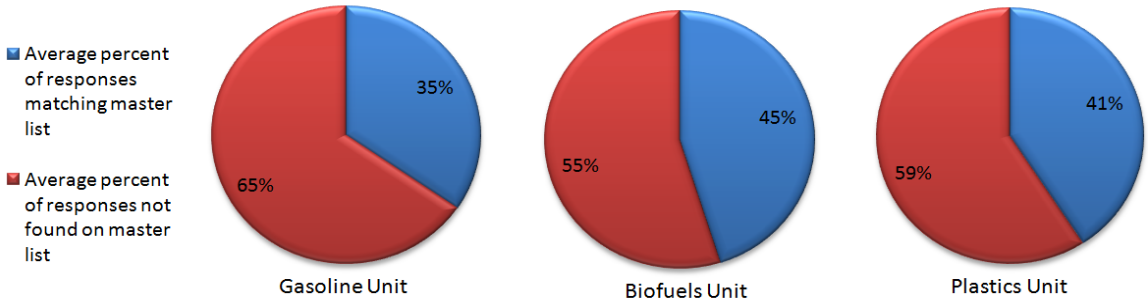


Figure 4. Percent of Focused Listing responses matching master list, (*N*=4).

In analysis of the listed words that were used during unit instruction, almost three quarters of those recorded had been used at some point in classroom activities. The remaining fraction tended to be words that symbolized more of a personal connection (Figure 5). These personal connection words in the Gasoline unit tended to be more sensory, such as “pungent,” “tastes horrible,” and “smells bad.” In the Biofuels unit, the personal connection words and phrases seemed to be tangent thoughts that came from some of the relevant listed items. These included such words and phrases as “healthy,” “Subway…eat fresh,” and “Easter.” In the Plastics unit, the personal connection words tended to be examples of plastic items like “cups,” “lids,” “speakers,” “dust pans,” “pens,” “Barbie,” “tape,” and “toys.”

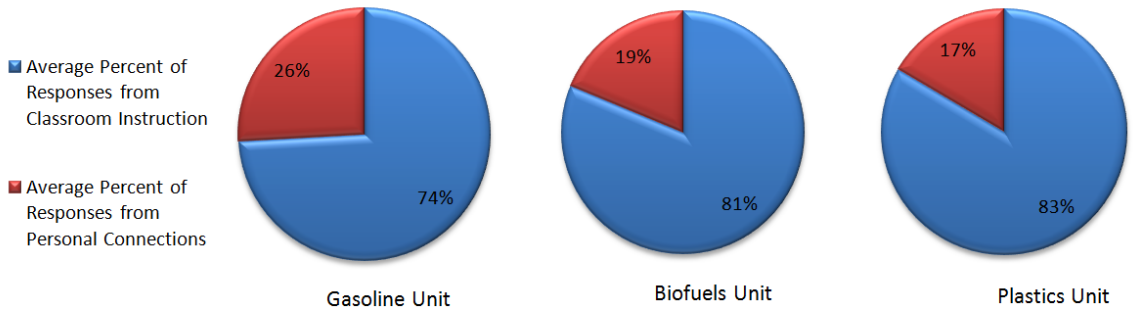


Figure 5. Percent of Focused Listing responses stemming from classroom instruction versus personal connections, (*N*=4).

During instruction, students would ask questions and tell stories that related happenings outside the chemistry classroom to concepts we were studying. In particular, Student 2 explained how her car had broken down the day before and her dad had to change the air filter. In conjunction with the recent combustion lesson, she was able to explain how having a dirty air filter was affecting her engine, and she was quite pleased that she was able to impress her father with her new knowledge.

Learning was furthermore assessed through Daily Diagnostic Learning Logs, which were examined to see if students' statements of their learning matched the learning objective for the day's lesson. The data showed that as the class progressed through the units, the students seemed to more often see their learning differently than the learning objective for the day (Figure 6). In the beginning Gasoline unit, students stated their learning to be the same as or similar to my written learning objective an average of 84% of the time. However, as the study progressed, I noticed more statements describing actions rather than learning. In one instance Student 4 wrote, "We listened to a podcast about plastics." Another statement by Student 3 included, "We worked on a lab." The number of statements about the student's own performance and feelings also increased. For example, Student 2 wrote, "I learned that I, however awesome I may be, need to pay attention and carefully read and comprehend questions," and additionally commented after another lesson, "I learned that we failed miserably at today's lab." Also during this time, in my teacher journal, I observed steadily declining engagement in the activities towards the last two units, and students seemed to just be going through the motions.

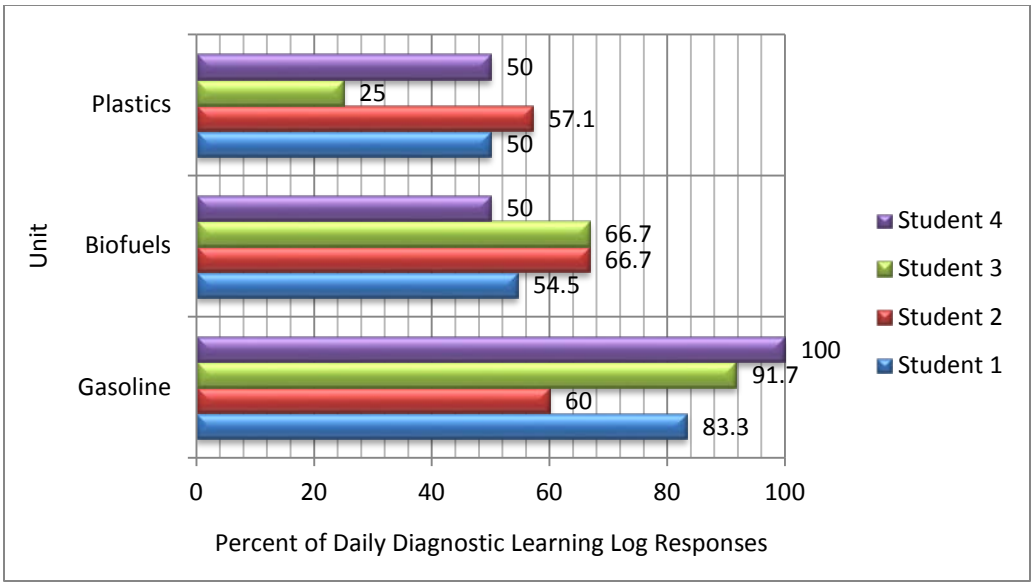


Figure 6. Percent of Daily Diagnostic Learning Log responses that matched lesson objectives, (*N*=4).

In regards to the depth of concept understanding, students tended to do very well on questions that involved an increase depth of knowledge. In two of the three units, the students had the highest average score on the level three questions (Figure 7). However, there were some common mistakes made among the Post-Probe responses. In the Gasoline unit, three of the four students were not able to recognize that an organic structure that had been rotated was not an isomer, but rather, the same structure. Also, when asked to apply some calculations to the concept of combustion, two students could not accurately calculate molar mass and complete the stoichiometry process. In the Biofuels unit, all students missed the question that asked them to write the reaction for biodiesel using the structures of each reactant and product. Furthermore, two students were not able to find correct bond energies and their work showed no indication of drawing out the molecules they were calculating bond energies for. On the Plastics Post-Knowledge Probe, three students were not able to identify the monomers of polypropylene, but responded ethylene or ethanol instead. Two students incorrectly drew

polymer structures with double bonds, and two students could not state the purpose of plasticizers even though they knew the problems with them.

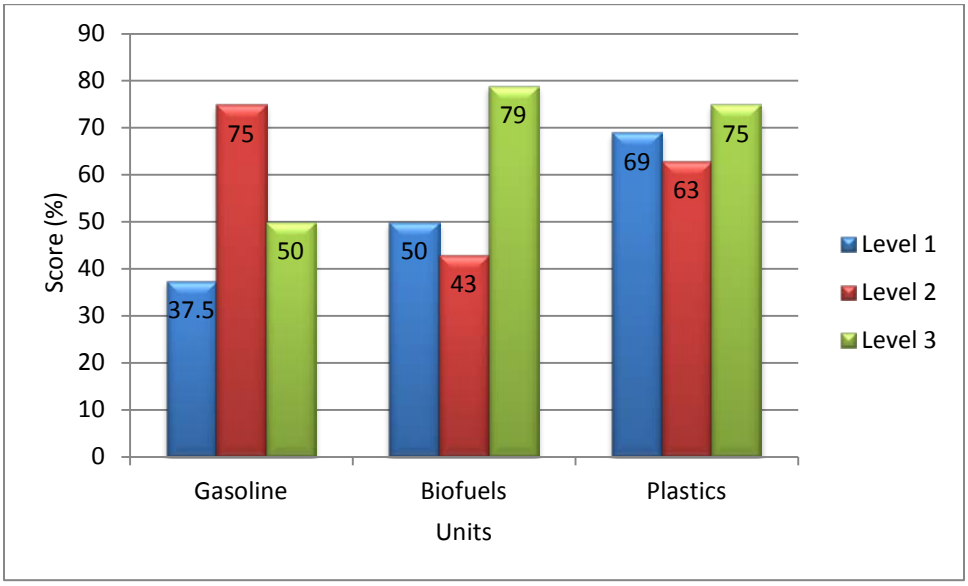


Figure 7. Post-Knowledge Probe scores for each depth of knowledge level, (*N*=4).

In examining data from the focused listing, two of the most frequently used words in the Gasoline unit, crude oil and octane, matched the master list, indicating an understanding of the concepts (Figure 8). However, the other two most frequently used words, pumps and cars, indicated less conceptual understanding, but more of an application of content to what the students encounter outside of class. In the Biofuels and Plastics units, the four most frequently listed words all matched words on the master list.

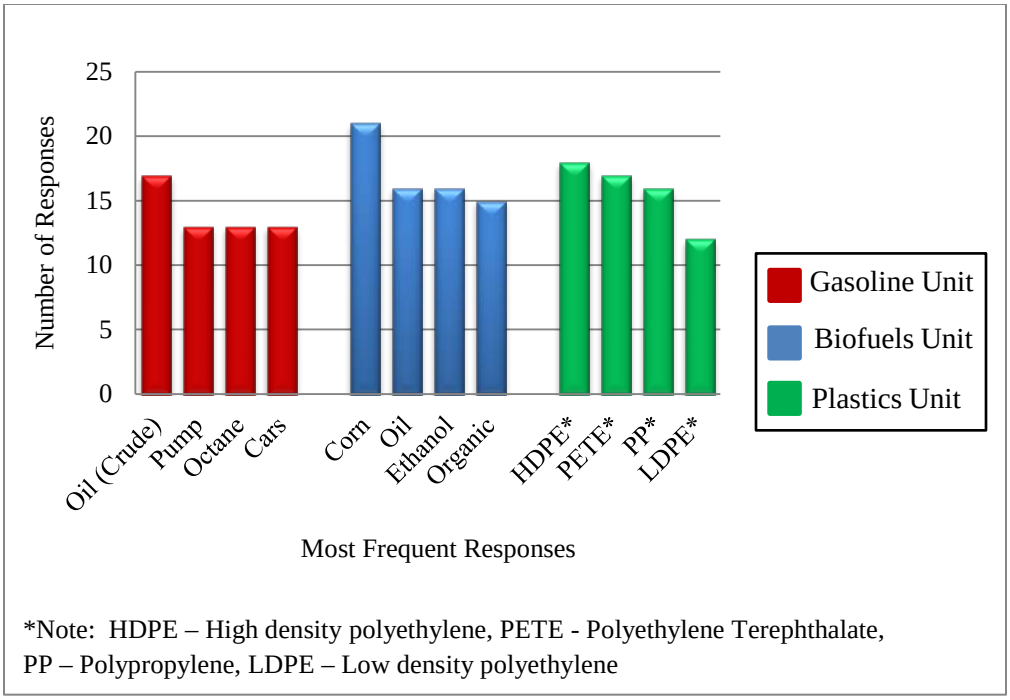


Figure 8. Most frequent Focused Listing responses, (*N*=4).

Another indicator from the focused listing was the increase use of words matching the master list as the students progressed through the unit. In each section, the number of words that matched the master list at least doubled from the first focused listing of the unit to the last. Specifically in the Biofuels unit, the minimum increase was fivefold and the highest was eight times the number of matching words originally listed. The plastics unit even saw an increase of thirteen times that originally listed.

In examining students' attitudes of chemistry, each student expressed to me in Pre-study Interviews that they liked the subject of chemistry, and it was not overly apparent from in class behavior that the students' views changed throughout the study.

One particular student, Student 3, had future plans to become a nurse, and she often told me that taking this class was primarily to prepare her for a rigorous science study coming up in her college career. She stated, "I would much rather work harder now and be more prepared next year in college." In her Pre-study Interview, when asked

what she thought about the subject of chemistry, her answer was short and to the point, “I like it. I think it is interesting.” This student was often very involved in discussions throughout the treatment, and often came in with stories relating her life to content we were learning in class. In her Post-Interview she stated about chemistry “I like it a lot more now than I did at the beginning of the year. I think it is a lot more easier and fun to understand now and think about.”

Another student, Student 2, had mentioned to me before the study that he might major in chemistry because he found it so enjoyable. Before learning in context, when asked about what he thought about the subject of chemistry, he stated, “I like it; think it is challenging and pretty fun.” After the study, his Post-Interview still reflected an appreciation for the subject, but his answer seemed more articulated and held more meaning. He stated, “I like chemistry. I think it is very fun and meaningful. Like everything you learn in chemistry has to do with life and it makes you understand how the world really works rather than just walking around like oh, there's gasoline and plastics and polyethylenes. It changed how I thought about stuff.”

Only Student 1 seemed to change their opinion negatively throughout the course of this study. When asked about her thoughts of chemistry in the Pre-study Interview, she simply stated “I like it.” Throughout the treatment, this student seemed to take on a very apathetic attitude, and when asked again after the study about her thoughts on chemistry she stated “I sometimes like chemistry, but when it gets challenging I tend to give up. There are so many interesting topics that involve chemistry.”

As the class progressed through the in-context units, it was evident that a large variable in attitudes was the classroom environment. The students really enjoyed having

such a small class, and each student at some point, mentioned their satisfaction due to the classroom environment. In the Post-study Interviews two students directly mentioned the small class size as a factor in their opinion of chemistry class. Student 2 said "I like how it is small and it is more exciting. I like how we do more labs, and its quicker and easier and its laid back and we are all on the same page of knowledge so we can apply it." Additionally, Student 1 mentioned something along the same lines, "I absolutely love our chemistry class. With only a class of 4 it makes it a lot easier to learn."

Another indicator of student attitudes was the CLASS-Chem survey administered before and after the study. The shift in favorable responses from pre-study to post-study was overall negative (Figure 9). Only one category of questions, Atomic-Molecular Perspective, showed a favorable response shift with an average 16.7% shift towards more expert-like thinking. This was also the greatest positive or negative change in attitude in any of the categories, indicating there were no large, overly significant changes.

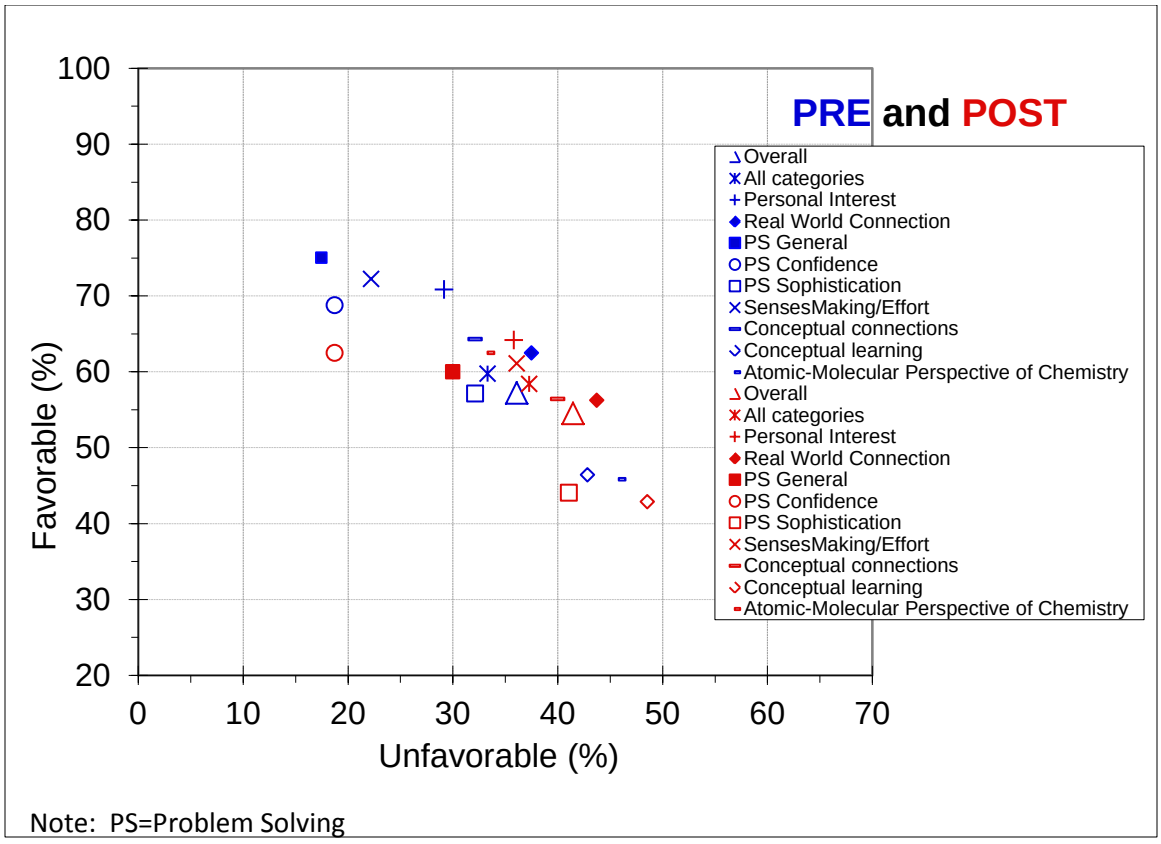


Figure 9. Pre and post-study average response shifts in CLASS-Chem question categories, (*N*=4).

The categories seeing the largest negative effect included a 13.9% novice-like shift in sense-making effort. This category involved questions about the value of exerting effort to make sense of concepts and problems in chemistry. This shift did not seem to correlate with the interview responses that showed many of the students enjoyed the challenging aspects of chemistry, however, it did match with Student 1's statement of "I sometimes like chemistry, but when it gets challenging I tend to give up."

Another large negative shift was seen in the similar categories of Problem Solving(PS)-General (12.5%) and Problem Solving(PS)-Sophistication (8.9%). These categories asked questions pertaining to methods and attitudes that students have towards solving problems encountered in their chemistry study, and this negative shift indicates

the students feel less able to succeed when they come across difficult situations. Statements such as “I know more about plastics than what I thought” and “It doesn't seem that we learn a lot but when I go to take my test and I find out that I learned a lot more than I thought I did” show that students were rather unsure about their knowledge until they were given a chance to show what they knew.

Even with the average negative shifts in the question categories for the class, two of the four students had positive shifts toward more expert-like thinking over the course of the study (Figure 10). Three out of the four students showed very little change in attitudes, a 10-20% shift, while only one student seemed to have a large (-30 to -40%) negative shift.

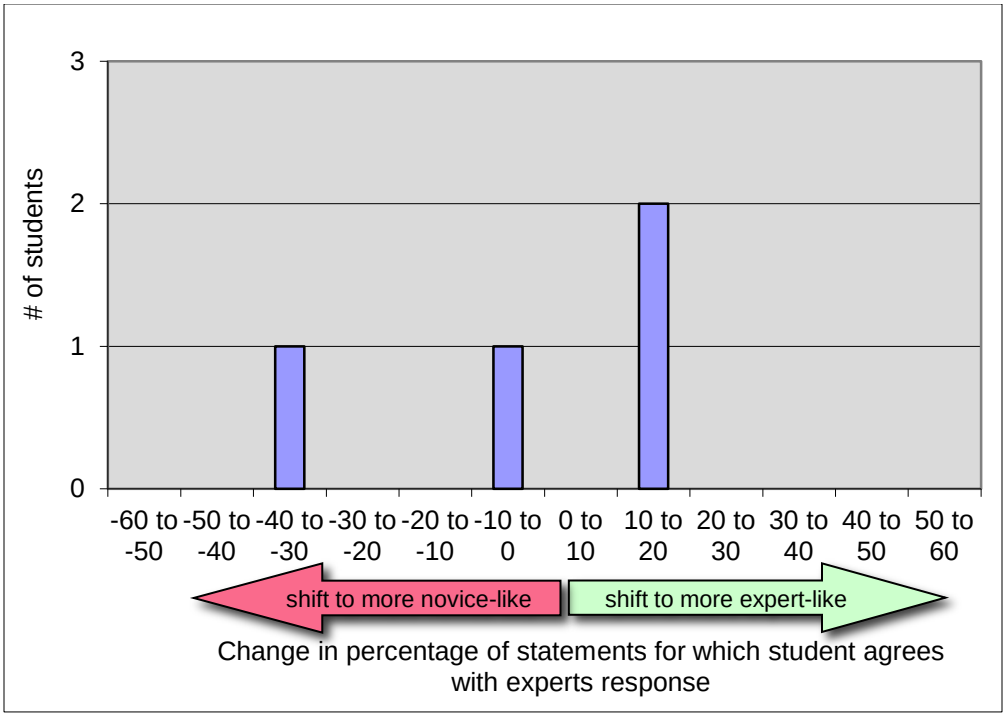


Figure 10. Quantity and percentage of change of students with expert and novice-like shifts, (*N*=4).

INTERPRETATION AND CONCLUSION

The first goal of this study was to assess how a *science-technology-society* (STS) approach affects learning of content, and the new style of teaching seemed to have a positive effect on learning as Post-Knowledge Probe results were strikingly better quality than the pre-test. Even though class discussions contained many sidebar topics, students were still able to identify the concepts they learned, which often did match learning objectives. I feel that many of the details that were conversed about during tangent dialogues only added to the depth of the context and helped the students make more connections. Elevated scores on Post-Knowledge Probes further indicated a deeper level of understanding for the Biofuels and Plastics units compared to the Gasoline unit.

The difference in Post-Knowledge Probe scores of Student 4 compared to the other students was quite drastic. In reviewing this student's attendance, it was noted that she missed almost 30% of the gasoline unit and near 70% of the plastics unit due to school activities. The class work was made up, but there was still a negative difference in knowledge and understanding. I felt that this variation was due to a lack of in class discussion as much of the learning in an in-context situation comes from students asking questions and feeding on each other's ideas in class. When all four students were present there were many tangent topics as students would make one connection and then another. These occasions were much less frequent if one or more students were missing. To try to remedy this I tried having the students teach other students that were absent for a class. However, I observed that each individual held onto key ideas and they had a hard time articulating how all their pieces went together.

The second goal of this study was to examine the effect of teaching in context on the depth of concept understanding. According to the Post-Knowledge Probe scores, the depth of student understanding did increase. The fact that students achieved success on level three questions indicated that they were not just memorizing, but that they truly understood and were able to apply the learned concepts to other topics. The Knowledge Probe in the Gasoline unit indicated the students seemed to have a problem distinguishing between isomers and structures that were the same, which I feel is a tougher concept for students to grasp because it involves a lot of spatial thinking. More practice with this could have helped. Also, the fact that the students could not complete the stoichiometry process on one of the questions tells me that certain skills I thought they had from their previous year of chemistry may have been lacking. In the Biofuels unit, two of the students did not draw out the structures of molecules to find bond energies, even though this is how we practiced, and none of the students were able to draw the biodiesel reaction using molecular structures. I feel that this reluctance to draw structures also comes from the previous year of chemistry as I learned that prior instruction had a lack of atomic-molecular structure practice. Finally, in the Plastics unit, the molecular structure trend continued, as students were not able to recognize incorrect atomic structures when they drew polymers that still contained double bonds. This could also be a sign that the students did not truly understand the polymerization reaction.

I felt that the Focused Listings also indicated a deeper level of understanding because more connections are made with well-understood topics. Therefore, the increase in associations with the subject can be attributed to a deeper understanding. Associating content terminology with a topic is suggestive of assessing, apprising, comparing,

differentiating, and explaining phenomena in terms of concepts; which are all indicators of a level three depth of knowledge according to the *Web Alignment Tool*.

The large number of associations that the students made with the in-context subjects was quite apparent with the focused listing and classroom discussions. However, the Biofuel unit, I felt, was the one they identified with the least. This surprised me, as one of the most popular Biofuels is ethanol, a product made right in their community. One way to see the students become more invested in an in-context topic may be to let the students suggest issues they are interested in, and incorporate learning chemistry content into those issues. A prior interest in the subject matter could create even more associations in the students' minds.

This final goal of this study was to find the effect of in-context teaching on student attitudes towards chemistry. As an elective class, I assumed that the students who took advanced chemistry already had some interest in the subject, or at least had some underlying motive for taking the course. I never felt that I was ever working hard to get the students to like the subject. It was noted that throughout the time of the study, general interest in the coursework decreased. The Daily Diagnostic Learning Logs were a prime example of this, as the Gasoline unit Logs tended to be a lot more detailed and content-related than the final Plastic unit. However, I am not sure if this was due to the style of teaching or rather that students were losing enthusiasm for school in general since most of them were seniors and close to graduating.

During interviews, my students had positive to moderately positive things to say about the subject of chemistry and how they learned in class. Many comments about the class were directly related to learning about chemistry in the real world. However, the

satisfaction could also be a result of the classroom environment as many students voiced their approval with the class due to the small size. A different teaching style, therefore, may not be the only contributing factor to changing attitudes.

Even though the survey indicated only one area of more expert-like attitudes, two of the four students showed an overall increase in opinion. I believe that the novice-like feelings were due to the different style of teaching, which the kids were not used to. This could be remedied by more in-context teaching, or with more teacher-led practice in problem solving with applications of chemistry. Considering the specific student, Student 1, that had a declining attitude in interviews, I felt that she thought the content was interesting, but the difficulty of the concepts and lack of the comforting worksheets and bookwork affected her attitude on the entire subject.

VALUE

The experience of developing and conducting this capstone project has had some key impacts on my teaching style and habits. First, I find myself trying to find worth and meaning in the content I teach. I realize that in my mind these concepts are held in high esteem, however, my students are still trying to find that value. With teaching in-context, students are given that connection that ties the content into their own lives. In this study I noticed that what I thought were interesting topics were not necessarily motivating for my students. From this observation, my goal is to try to get to know my students better, ask them what they are interested in, and try to incorporate into class topics that are currently affecting their lives and have meaning to them.

Another impact is my new-found determination not to become the teacher that has a whole year's worth of lesson plans ready to go at a moment's notice. There are always those go-to lessons that can make an impact, but in order to help my students find meaning in the content I must be willing to change. I now look for new and innovative ways to teach, and I also look for current and meaningful ways to associate the content with my student's lives. Science is always changing and it is important to incorporate new ideas.

I find that after this project I seek out opportunities to work with other teachers and share ideas. Being in a new teaching situation, I am currently taking steps to increase the communication within my department and school. I have spear-headed a science club to get our kids more involved and I have sought out involvement from science teachers as well as others. I have applied for summer professional development opportunities and encouraged others in my department to do the same. Furthermore, I have taken the initiative to communicate with higher level educators in order to create opportunities for my students.

I believe that an in-context style of teaching does have value and I look forward to the opportunity to research the topic further in the future. I am always actively seeking out new ways to incorporate content into meaningful themes, and there are many new *Science-Techonology-Society* curriculums to be explored. Conferences and workshops continuously have new ideas and techniques, and I am excited to find top-notch teaching strategies that engage my students as well as deliver quality content.

Finally, this project has convinced me even more that I need to make my students see the science in their everyday life. My project idea developed from this goal and my

observations just reinforced it. I was shocked with some of the general knowledge that my treatment group lacked as we went through topics that I felt good citizens should be educated on. In order for the next generation to be science literate and make informed decisions on energy, environmental issues, and health and safety issues, we must teach our children science concepts that relate to their world.

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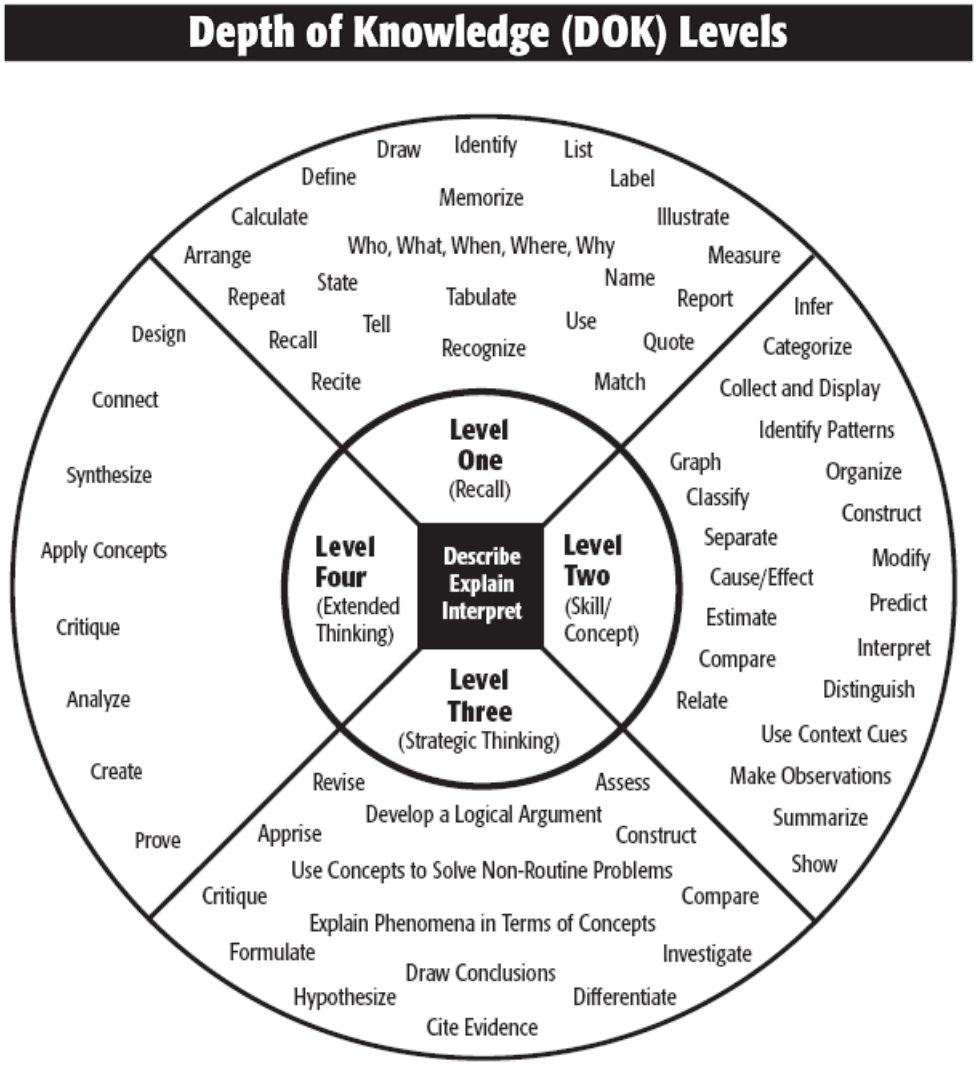
APPENDICES

APPENDIX A

WEB ALIGNMENT TOOL

Appendix A

Web Alignment Tool



Level One Activities	Level Two Activities	Level Three Activities	Level Four Activities
Recall elements and details of story structure, such as sequence of events, character, plot and setting.	Identify and summarize the major events in a narrative.	Support ideas with details and examples.	Conduct a project that requires specifying a problem, designing and conducting an experiment, analyzing its data, and reporting results/ solutions.
Conduct basic mathematical calculations.	Use context cues to identify the meaning of unfamiliar words.	Use voice appropriate to the purpose and audience.	Apply mathematical model to illuminate a problem or situation.
Label locations on a map.	Solve routine multiple-step problems.	Identify research questions and design investigations for a scientific problem.	Analyze and synthesize information from multiple sources.
Represent in words or diagrams a scientific concept or relationship.	Describe the cause/effect of a particular event.	Develop a scientific model for a complex situation.	Describe and illustrate how common themes are found across texts from different cultures.
Perform routine procedures like measuring length or using punctuation marks correctly.	Identify patterns in events or behavior.	Determine the author's purpose and describe how it affects the interpretation of a reading selection.	Design a mathematical model to inform and solve a practical or abstract situation.
Describe the features of a place or people.	Formulate a routine problem given data and conditions.	Apply a concept in other contexts.	
	Organize, represent and interpret data.		

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APPENDIX B

PRINCIPAL CONSENT

Appendix B

Principal Consent

Exemption Regarding Informed Consent

I, Dan Hadden, Principal of Ogallala High School, verify that the classroom research conducted by Jennifer Hayes-Jones is in accordance with established or commonly accepted educational settings involving normal educational practices. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Jennifer Hayes-Jones regarding informed consent.

Dan Hadden, Principal

(Signed Name)

Dan Hadden, Principal

(Printed Name)

10/24/11

(Date)

APPENDIX C

GENERAL TIMELINE OF PROJECT

Appendix C

General Timeline of Project

Unit	Theme	Lesson	Chemistry Content Objectives	Lesson Content
1	Gasoline	Prior to start	N/A	Background Knowledge Probe
		1	Describe crude oil in terms of where it comes from, how it is made, and what it is composed of.	FL Student discussion of prior knowledge Table of Crude oil products Teacher-led HC notes DLL
		2	Recognize, compare, and draw the structures of alkanes, alkenes and alkynes	FL Review crude oil composition Teacher-led HC notes Students practice making HC with molecule kits and drawings DLL
		3	Recognize, compare, and draw structural isomers of alkanes, alkenes, and alkynes.	FL Review HC structures Teacher-led isomer lesson Students practice identifying and drawing isomers DLL
		4	Make observations and compare BPs of various HCs.	FL Student discussion of HC properties using examples Teacher-led boiling point notes DLL
		5	Explain BP of HC in terms of HC structure.	FL Overall review of structures, isomers and properties Review BP Teacher-led Fractioning Tower and Distillation discussion Students explore fractionation with online animations DLL
		6	Make observations and describe the process of distillation.	FL Distillation of Cherry Coke Lab DLL
		7	Understand the physical and chemical principles	FL Finish and discuss distillation

			associated with petroleum refining and cracking.	lab Examine petroleum usage chart and justify cracking Video on Cracking DLL
		8	Explain the difference between complete and incomplete combustion.	FL Guided inquiry discussion on complete and incomplete combustion with Bunsen burner demo (carbon residue on beaker) Teacher-led combustion practice Combustion engine discussion DLL
		9	Describe how octane ratings are assigned and explain how the refining process and use of additives affect octane ratings and why formulated and oxygenated gasolines are used.	FL Review Incomplete/complete combustion Present TEL and MTBE articles Student research on gasoline octane and additives DLL
		10	Describe how octane ratings are assigned and explain how the refining process and use of additives affect octane ratings and why formulated and oxygenated gasolines are used.	FL Review complete and incomplete combustion Discuss TEL and MTBE and student presentations Overall review of concepts DLL
		11	N/A	FL Background Knowledge Probe
2	Biofuels	1	Compare and contrast different biofuels and fossil fuels.	Background Knowledge Probe FL Fuel consumption graph and alternative fuel discussion Teacher-led Biofuels lecture Biomass and corn – where does the energy come from prediction DLL
		2	Investigate a corn kernel to draw conclusions about the production of corn ethanol.	FL Dissect a corn kernel lab DLL

		3	Compare and contrast structures of HC fuels to ethanol, and biodiesel.	FL Students research molecular structure of ethanol and biodiesel Teacher-led notes on functional groups and identify any group present in fuels DLL
		4	Recognize, compare and draw organic compound functional groups.	FL Review functional groups of fuels Students practice recognizing, naming and drawing organic functional groups Teacher-led discussion of functional group isomers Students examine and predict ethanol properties DLL
		5	Recognize, compare and draw organic compound functional groups.	FL Review functional groups of fuels Students practice recognizing, naming and drawing organic functional groups DLL
		6	Make observations and use correct lab technique to complete esterification reactions.	FL Esterification Lab: “The smelliest lab of the year” DLL
		7	Make observations and use correct lab technique to synthesize biodiesel.	FL Review ethanol and production Discuss biodiesel properties and production DLL
		8	Make observations and use correct lab technique to synthesize biodiesel.	FL Make biodiesel lab DLL
		9	Make observations and use correct lab technique to find the energy content of biodiesel.	FL Energy content of fuels lab DLL
		10	Calculate bond energies of biofuel molecules.	FL Finish and discuss labs Teacher-led lecture on bond energies

				Review energy content and efficiency DLL
		11	N/A	Background Knowledge Probe
3	Plastics	1	Understand the prevalence of plastics in society.	Background Knowledge Probe FL Finding plastics activity Plastic usage graph analysis Teacher-led discussion of where plastics come from, monomers and polymers Types of Plastics (the Big Six) DLL
		2	Match the properties and structures of the "Big Six" polymers with their uses.	FL Teacher-led discussion of types of plastics and properties Make nylon demo DLL
		3	Recognize and draw the molecular mechanism of addition polymerization.	FL Discuss plastics properties lab Teacher-led discussion of addition polymers Addition polymer demo Student practice in writing addition reactions Types of addition polymer plastics Polyacrylate demo to show other properties/uses DLL
		4	Compare and contrast condensation polymerization with addition polymerization.	FL Teacher-led discussion of condensation polymers Student practice in writing condensation reactions Types of addition polymer plastics Examine different types of plastics and compare Teacher-led notes on plasticizers DLL
		5	Make observations and use proper lab technique to synthesize a polymer	FL Gluep Lab DLL
		6	Make observations to relate	FL

			cross-links in polymers to structure and properties.	Finish and discuss Gluep Lab Discuss cross-linking and polymer structure/properties. Online animations to review concepts
		7	Explain the significance of plasticizers in making polymers and their effects on health.	FL Plasticizers podcast with follow-along questions Discuss plasticizers and additives DLL
		8	Make observations and use proper lab technique to test the effects of plastic combustion.	FL Plastics as fuel lab DLL
		9	Relate the technical, economic, and political issues in methods for disposing of waste plastic: incineration, biodegradation, reuse, recycling, and source reduction.	FL Finish and discuss lab Teacher-led discussion on implications of combustion byproducts Review all polymer concepts DLL
		10	N/A	Background Knowledge Probe

APPENDIX D

CLASS-CHEM SURVEY

Appendix D

CLASS-Chem Survey

Here are a number of statements that may or may not describe your beliefs about learning chemistry. You are asked to rate each statement by choosing a number between 1 and 5 where the numbers mean the following:

1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

Choose one of the above five choices that best expresses your feeling about the statement. If you don't understand a statement, leave it blank. If you understand, but have no strong opinion, choose 3.

Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime.

Your participation or non-participation will not affect your grade or class standing.

Survey Questions:

1. A significant problem in learning chemistry is being able to memorize all the information I need to know.

2. To understand a chemical reaction, I think about the interactions between atoms and molecules.

3. When I am solving a chemistry problem, I try to decide what would be a reasonable value for the answer.

4. I think about the chemistry I experience in everyday life.

5. It is useful for me to do lots and lots of problems when learning chemistry.

6. After I study a topic in chemistry and feel that I understand it, I have difficulty solving problems on the same topic.

7. Knowledge in chemistry consists of many disconnected topics.

8. As chemists learn more, most chemistry ideas we use today are likely to be proven wrong.

9. When I solve a chemistry problem, I locate an equation that uses the variables given in the problem and plug in the values.

10. I find that reading the text in detail is a good way for me to learn chemistry.

11. I think about how the atoms are arranged in a molecule to help my understanding of its behavior in chemical reactions.

12. If I have not memorized the chemical behavior needed to answer a question on an exam, there's nothing much I can do (legally!) to figure out the behavior.

13. I am not satisfied until I understand why something works the way it does.

14. I cannot learn chemistry if the teacher does not explain things well in class.

15. I do not expect equations to help my understanding of the ideas in chemistry; they are just for doing calculations.

16. I study chemistry to learn knowledge that will be useful in my life outside of school.

17. I can usually make sense of how two chemicals react with one another.

18. If I get stuck on a chemistry problem on my first try, I usually try to figure out a different way that works.

19. Nearly everyone is capable of understanding chemistry if they work at it.

20. Understanding chemistry basically means being able to recall something you've read or been shown.

21. Why chemicals react the way they do does not usually make sense to me; I just memorize what happens.

22. To understand chemistry I discuss it with friends and other students.

23. I do not spend more than five minutes stuck on a chemistry problem before giving up or seeking help from someone else.

24. If I don't remember a particular equation needed to solve a problem on an exam, there's nothing much I can do (legally!) to come up with it.

25. If I want to apply a method used for solving one chemistry problem to another problem, the problems must involve very similar situations.

26. In doing a chemistry problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem.

27. In chemistry, it is important for me to make sense out of formulas before I can use them correctly.

28. I enjoy solving chemistry problems.

29. When I see a chemical formula, I try to picture how the atoms are arranged and connected.

30. In chemistry, mathematical formulas express meaningful relationships among measurable quantities.

31. We use this statement to discard the survey of people who are not reading the questions. Please select agree (not strongly agree) for this question.

32. It is important for the government to approve new scientific ideas before they can be widely accepted.

33. The arrangement of the atoms in a molecule determines its behavior in chemical reactions.

34. Learning chemistry changes my ideas about how the world works.

35. To learn chemistry, I only need to memorize how to solve sample problems.

36. Reasoning skills used to understand chemistry can be helpful to me in my everyday life.

37. In learning chemistry, I usually memorize reactions rather than make sense of the underlying physical concepts.

38. Spending a lot of time understanding where mathematical formulas come from is a waste of time.

39. I find carefully analyzing only a few problems in detail is a good way for me to learn chemistry.

40. I can usually figure out a way to solve chemistry problems.

41. The subject of chemistry has little relation to what I experience in the real world.

42. There are times I solve a chemistry problem more than one way to help my understanding.

43. To understand chemistry, I sometimes think about my personal experiences and relate them to the topic being analyzed.

44. Thinking about a molecule's three-dimensional structure is important for learning chemistry.

45. It is possible to explain chemistry ideas without mathematical formulas.

46. When I solve a chemistry problem, I explicitly think about which chemistry ideas apply to the problem.

47. If I get stuck on a chemistry problem, there is no chance I'll figure it out on my own.

48. Spending a lot of time understanding why chemicals behave and react the way they do is a waste of time.

49. When studying chemistry, I relate the important information to what I already know rather than just memorizing it the way it is presented.

50. When I'm solving chemistry problems, I often don't really understand what I am doing.

APPENDIX E

PRE AND POST-TREATMENT INTERVIEW QUESTIONS

Appendix E

Pre and Post-Treatment Interview Questions

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. Tell me what you think about the subject of chemistry.

2. Tell me what you think about chemistry class.

3. How do you learn chemistry content best? What is the best way you learn chemistry content?

4. How applicable is the chemistry you learn in school to your life?

5. What connections can you make between chemistry and your real life? Please explain the connections.

6. How often do you think about chemistry and its role in your daily routine?

7. Is there anything else you would like me to know?

APPENDIX F

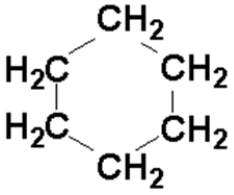
GASOLINE UNIT BACKGROUND KNOWLEDGE PROBE

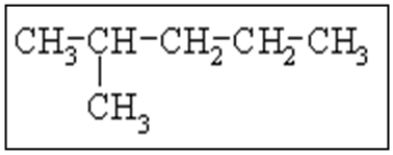
Appendix F

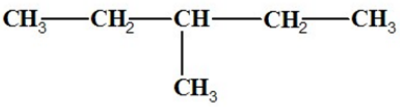
Gasoline Unit Background Knowledge Probe

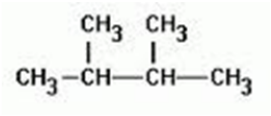
Please answer the following questions to the best of your ability.

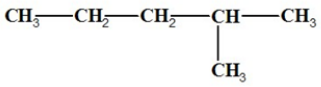
1. Circle the structure(s) that is/are isomer(s) of the boxed structure:



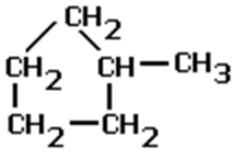








2. Write the name of the following hydrocarbon: _____

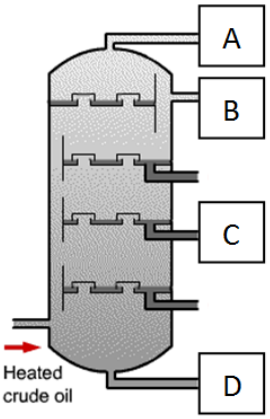


3. Draw an isomer of the hydrocarbon that does not contain a ring. Show all bonds and atoms.

4. Write the balanced equation for the complete combustion of the hydrocarbon.

5. Given 168 g of the hydrocarbon, how many grams of CO_2 will you produce?

6. The image at right shows a distillation tower. Crude oil enters from the left and is refined into various fractions.



   a. First, if a C_6H_{14} exited through pipe B, would you expect $C_{14}H_{30}$ to exit through pipe C or A? Explain your choice.

   b. Now, what property is being exploited to separate the fractions (< 5 words)?

APPENDIX G

BIOFUELS BACKGROUND KNOWLEDGE PROBE

Appendix G

Biofuels Background Knowledge Probe

Answer each question to the best of your ability.

1. Draw 1-propanol and isomer of propanol that is an ether.

2. Draw the structure of a triglyceride (a triple ester).

3. Show how reacting the triglyceride in the presence of a base will form biodiesel (triple ester + alcohol →_____ + _____)

4. One way to produce ethanol is the reaction of water vapor with ethylene:

$$CH_2CH_{2(g)} + H_2O_{(g)} \rightarrow CH_3CH_2OH_{(l)}$$

Using given bond energies, is this reaction endo- or exothermic?

In your calculation, was it necessary to break and form all the bonds in the reaction? Explain.

APPENDIX H

PLASTICS BACKGROUND KNOWLEDGE PROBE

Appendix H

Plastics Background Knowledge Probe

Answer all questions to the best of your ability.

1. Polypropylene is an addition polymer.

    a. Tell what adds to what by filling in the blanks.

    _____ adds to_____

    b. Write the balanced chemical reaction for the polymerization of "n" molecules of propylene (propene) to form polypropylene.

2. Both HDPE and LDPE are made from the same monomer, however, they have slightly different properties. Explain how the plastics' molecular arrangement leads to its differing properties.

3. Describe two differences between an addition polymerization reaction and a condensation polymerization reaction.

4. Plasticizers are added to PVC to _____ them and the drawback of plasticizers is that _____

APPENDIX I

FOCUSED LISTING MASTER LISTS

Appendix I

Focused Listing Master Lists

	Focused Listing Prompt		
	Gasoline	Biofuels	Plastics
Master List of Words used for comparison	• Crude Oil • Hydrocarbons • Octane • Octane Rating • Fossil Fuels • Drilled from ground • Expensive • Supply and demand • Combustion • Complete combustion • Incomplete combustion • Fractional Distillation • Fractions • Oxygenates • TEL • MTBE • Ethanol • Additives • Isomers • Combustion engine • Reforming • Fuel • Unleaded • Boiling Point • Plankton • Alkanes (including specific names) • Alkenes • Alkynes • Organic • Cracking • Diesel • Jet fuel • Kerosene	• Ethanol • Biodiesel • Corn • Soybeans • Germ • Endosperm • Hull/tip cap • Pericarp • Biomass • Organic matter • Wood/plants • Peanuts • Vegetable oil • Sugar cane • Expensive/cheap • Combustion • Carbon neutral • Coconut • Photosynthesis • Grasses • Lower C emissions • Algae • Cellulose • Renewable • Glucose/sugars • Functional groups • Esters • Amines • Amides • Alcohol • Carboxylic acids/Fatty acids • Ethers • Triglycerides/fat • Endothermic • Exothermic • Energy • Bond energy • Biodegradable • E-85 • Palm oil	• HDPE • LDPE • PS • PP • PVC • PETE • Polymer • Monomer • Addition • Condensation • Water bottles • Containers • Hard to break down • Plasticizers • Chain reaction • Additives • Leaching • DEHP • BPA • Phthalates • Crude oil • Cellulose • Glucose • Nylon • Tires • Blood transfusions • Estrogen mimic • Combustible • Recyclable • Cross-links

APPENDIX J

DAILY DIAGNOSTIC LEARNING LOG

Appendix J

Daily Diagnostic Learning Log

Date:

Activities completed today:

1. List the main points you learned from class today. Give examples if possible.

2. List points from class today that are unclear to you. Give examples if possible.

3. Write a few questions that you need answers to before you can understand the points listed in #2.