EFFECTS OF REAL-WORLD CONTEXTS ON LONG-TERM MEMORY AND THE UNDERSTANDING OF CHEMISTRY CONCEPTS IN THE HIGH SCHOOL CLASSROOM

by

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In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

Robin Henrichs

July 2013

DEDICATION

This is dedicated to my family and friends, who supported and helped me go back for another degree.

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ABSTRACT

This study investigated the effects of using real-world contexts on long-term memory and understanding of chemistry concepts for 65 students in a high school chemistry class. Students were taught chemistry concepts using real-world topics as the basis. Data collection tools, including pre and postassessments, surveys, interviews, and observations, were used to gauge the level of student understanding, motivation, and teacher attitude and motivation. The data showed that using real-world contexts positively affected the students' understanding of chemistry concepts, long-term memory, motivation, and the teacher's attitude and motivation.

INTRODUCTION AND BACKGROUND

When first thinking about my capstone project, I wanted to focus on something that I could make beneficial to all my classes after the project was completed. Upon reflection, I was primarily looking at a possible change in my teaching methods. I decided to focus my capstone project on improving student learning in chemistry by making the content relevant to their daily lives using real-world contexts.

Over the past couple of years, I have seen a drop in my students' motivation to learn the concepts in my classes. Students generally have the attitude that they will never use the material in the real-world. My hope is that through this project I can help students see the science that is going on around them in their daily lives and to see science in their futures.

I believe that students who can appreciate the place that science takes in their daily lives and possible future careers will achieve higher in science classes. Their improved achievement is vital to our school. As with most states, Nebraska has instituted a standard-driven form of education, with teacher evaluations and educational funding dependent on student performance. There is a strong focus on encouraging all of our students to work to the level of their ability. I hoped that through this project I would develop some new methods to use in the classroom that would benefit our whole science department in improving our students' achievement.

I have been teaching at McCook Public Schools for 15 years. In those years I have always taught chemistry and physics along with various classes. McCook is a fairly rural school district by most accounts. The high school contains on average around 400 students. The majority of the students' parents works either in the manufacturing plants, for the railroad, or in agriculture. McCook's population is predominantly White with a few Hispanic families. I chose to use my chemistry class as the focus for my capstone project, in

part because the students have the widest range of academic ability in this class. I chose to focus the project around topics that have typically given students trouble; chemical reactions, stoichiometry, and solutions.

My project question was: What are the effects of using relevant real-world contexts on the understanding of chemistry concepts? Once I established my focus question that allowed me to develop sub-questions for my capstone. My project sub-questions were as follows: what are the effects of relevant real-world contexts on the long-term memory of chemistry concepts; what are the effects of relevant real-world contexts on student's attitudes and motivation; what are the effects of real-world contexts on my attitude and motivation?

My Capstone Advisor for this project was Jewel Reuter, PhD. Chris Bahn, PhD. was my Montana State University reader for the project. I chose Chris for his experience in the field of chemistry. For my support team, I asked some of my colleagues and a former teacher of the district. The first person was Barry Schaeffer, he is a close friend who has left the district and is now a principal. He has a very good background in student behavior. The next person is my school Principal Jerry Smith; he is a former science teacher and provided excellent feedback on peer observations. The last person of the team is a colleague Pam Wolford who is the head of the English Department. I feel her expertise in writing will be extremely helpful in the finishing touches of the paper. In most cases I interacted with these people individually. The interactions with Barry were through email mostly. The other two members were face to face discussions throughout the year.

CONCEPTUAL FRAMEWORK

A review of the data in the literature showed a link in improved student understanding and motivation when connecting science concepts with real-world contexts. The contexts

seem to allow the student to establish a strong conceptual foundation for the subject. The studies also show that these contexts can greatly impact their engagement and enthusiasm for science. When a student participates in an activity of high interest, the activity can provide that student with a long lasting understanding and positive memorable experience, both of which greatly impact his or her learning experience.

Over the last several years, many studies have shown an increase in negative student attitudes toward science. The studies showed that the decline in interest is probably linked to the way science is traditionally taught. In most cases the traditional method is not able to make science meaningful and interesting (King, 2009).

In typical science classes, the instructor presents the material, students generally take notes, listen, and do labs. They rarely ask questions or develop their own ideas. Students' best learn a subject by tying it to a real-world context in such a way that they can make connections between the subject and its application to their lives (Taasoobshiraci & Carr, 2008). The goal of using real-world context in science is to allow students to apply previous knowledge, develop interests, and initiate a curiosity toward the materials at hand. This method is very similar to constructivism. According to the constructivist theory, knowledge is created by assimilating new information into existing constructs. The learner selects and transforms information, constructs hypotheses, and make decisions, relying on a cognitive structure to do so. Curriculum should be organized in a spiral manner so that the student continually builds upon what they have already learned (Mintzes, Wandersee, & Novak, 1998).

The use of a real-world context creates opportunities for students to make connections between the science concepts and increases the applications of these concepts (King, Bellocchi, & Ritchie, 2007). Studies show that students in high school physics classes who

perform conceptual analyses and applications show higher achievement in science assessments. In traditional physics classrooms students tend to focus on finding the right equations, manipulating them, and calculating an answer. This focus on the equations often results in students failing to grasp the real-world relationship of the content to their everyday lives as well as developing poor problem-solving strategies. The contextual approach helps students move from just solving problems toward understanding the principles and laws (Taasoobshiraci & Carr, 2008).

When it comes to teaching the concepts, the literature refers to teaching the scientific ideas on a need-to-know basis (Bennett & Lubben, 2006). The Salters Advanced Chemistry project led to a large-scale, mainstream context-based course, which was designed with three main hypotheses in mind. The first is that a student's motivation to learn is enhanced through the use of a context as starting point to foster interest. An example would be to introduce the question "How does the nose know?" Students would investigate the chemistry of smell, learning about molecular formulas, Lewis dot structures, bonding, and the shape and structure of molecules. The second is the use of 'student-centered', 'active learning' approaches to stimulate interest and motivation. Finally, teaching in contexts provides an equally good foundation as a conventional course (Bennett, Grasel, Parchmann, & Waddington, 2005).

While looking at the units for my capstone, I needed to be careful when I decided what real-world contexts I used. In previous years, I taught the concepts in a certain order. After all, teaching in context does not "teach the way we were taught". The need-to-know basis may require the instructor to let go of teaching one or more long-held favorite topics or teach these topics in far less depth (Middlecamp, 2008).

To better describe context-based instruction and its role in physics, a study by Taasoobshiraci and Carr describes a high school classroom in Georgia using this instructional approach. The classroom was made up of 17 students, including nine males and eight females in their senior year. The following observations were recorded on a day in which students were completing a lab to build their understanding of projectile motion. The students used a launcher that had been set up for them by instructor to determine where a plastic ball would land. This lab was preparing the students for another lab called Water Balloon Day, in which the students use the launcher to try to hit their instructor with water balloons. The students spend time before the main lab practicing how to measure the distance and angle to hit their instructor. Interviews with the students indicated that the students found the context-based problems to be more interesting than the traditional problems (Taasoobshiraci & Carr, 2008)

Of interest to me as part of my project are the effects of contexts on long-term memory. According to the literature about context-based instruction, students should be able to remember more of what they have learned because it has become more meaningful to them. The article by Bonner (2010) indicates that the student's immersion into a real-world application is a key component to learning being enhanced. In his study, he discussed how teachers could use a basic concept and bring it to life. The main objective was to make the event very engaging for the senior students in his physics class. Bonnor created an environment that was very visual and tactile for his students. He found that activities involving real-world events lead to a student's long-term understanding of physics concepts as evidenced by the students' performance on the summative assessments. One particular activity was setting up a crime scene portraying an actual event to study projectile motion. The effectiveness of the lesson becomes evident during the presentation portion. The

students displayed their findings and discussed them amongst the class. Having them display their findings gave voice and the opportunity for meaningful learning.

In an early study by King, Bellocchi, and Ritchie (2008), researchers looked at students enrolled in chemistry using a context-based approach; one student, Amanda, recounted her experiences. As an example of her making connections, she was able to connect the concepts of gas laws with real-world activities like scuba diving. Amanda and the grade 11 students in the study expressed a preference for the chemistry approach that makes connections to the real-world. Amanda commented that the context-based approach helped her make real-world connections to chemistry content and that this lead to an increase in her interest and engagement in chemistry.

In using a contextual approach, the data in several studies showed that students will be able to move away from viewing science as something to memorize or compute. A study by Akcay and Yager (2010) studied 365 students enrolled in a context-based science course and another 359 students enrolled in traditional science class. According to the study, students enrolled in the context-based class showed marked improvements in their attitudes toward science where the traditional students' attitudes remained largely unchanged.

A review done by Bennett, Lubben, and Hogarth (2006) looked at nine studies involving context-based curricula. Seven of the nine studies reported evidence that the context-based approach improved attitudes toward school science and science in general. The desire for using context-based material is that all students will feel more positive about science by helping them see the importance of why they are studying the concepts.

The use of contexts has also been shown to have a large impact on the teacher. The study by Whitelegg and Parry (1999) showed that teachers varied in their understanding of what context-based learning meant. Most of the teachers they interviewed simply felt that it

referred to the traditional teaching of science concepts with applications and everyday examples included. The overall success for context-based curricula depends heavily on the teacher's enthusiasm for the approach.

The practice of context-based teaching requires that a teacher fully develop and appropriately put the activities into practice. For most teachers, including me, beliefs and values about science education must be restructured (Mansour, 2009). However, in a study of 222 teachers, they agreed that a context-based course is more motivating to teach, but it was more challenging for them to prepare (Bennett, Grasel, Parchmann, & Waddington, 2005).

The main goal of context-based learning is to make concepts relevant to the student. This goal generally requires a change in philosophy and practices by the teacher. The teacher must add new methods to his/her instructional repertoire. The success of science education reform depends on a teacher's ability to integrate new philosophy and practices into existing philosophy (Mansour, 2009).

The context-based approach was developed based on the constructivist learning model. The model emphasizes the necessity of each learner to construct his/her own meaning, instead of just memorizing the information for assessments (Akcay & Yager, 2010). The model is divided into four phases, which are invitation, exploration, proposing explanations, and taking actions (Dass, Kilby, & Chappell, 2005). The constructivist model switches most classrooms from "teacher centered" to "student centered". The implications of this include an ample use of hands-on investigative lab activities, a classroom environment that provides for active cognitive involvement, use of cooperative strategies, and test items that activate a higher level of cognitive processes (Mansour, 2009). I used the information in Mansour's article as a guide when I developed my treatment activities.

In most everyday science classes, students generally don't see anything they are studying as having any relevance of application to their everyday lives. The literature suggests that it is best for educators to choose a context that is accessible to the student or build on a context suggested by a student themselves. Students get to learn about the context and the context determines what science content is covered (Whitelegg & Parr, 1999). Many studies have shown that if students are able to see how the work they are doing relates to their "real life" and have a greater sense of ownership in the class, they are more likely to be more motivated and successful in the area of science they are studying.

METHODOLOGY

Project Treatment

In order to measure the outcomes in my classroom based on the changes in teaching methods proposed by my action research project, I collected and compared data from both nontreatment and treatment groups of students. The initial nontreatment unit was taught with a traditional teacher-centered approach. This approach focused on the concepts of chemistry. The treatment units were taught starting with a real-world context and developed the chemistry concepts from the context. Essentially, the concepts were taught on a "need to know" basis, rather than in the traditional order.

In the nontreatment unit, the material being discussed was chemical reactions. Even though chemicals are very common in everyday life, only traditional teacher-centered methods were used in this unit. The students took a preunit assessment to get a base line of their knowledge. Once they completed the preunit assessment, I discussed the concepts of chemical reactions. The concepts included signs of a reaction, types, balancing, and predicting the products of a reaction.

The concepts in the nontreatment unit were introduced by lecture followed by a discussion. Once the concepts had been discussed in lecture, the students were then assigned the worksheet found in Appendix A and worked independently until completed. The worksheet required students to balance and classify several chemical equations. After the students finished the worksheet, they completed the lab found in Appendix B. The lab used was very quantitative in nature; it is what most teachers would refer to as a cookbook lab. They are not based on inquiry, so the students don't have a chance to form their own opinions.

The treatment units focused on relating real-world concepts and activities to the concepts of chemistry. The approach focuses on introducing real-life contexts to the students before the core content. The students learn about the context before they are introduced to the content. One key to this approach is to choose contexts that are accessible to the students. The more familiar the student is with the context or the context being a part of a student's everyday life the more motivated they are expected to be to learn the concept.

The main concept for the first treatment unit, the concept was stoichiometry. Stoichiometry is generally considered to be the math behind chemical reactions and is frequently the toughest material to grasp. In this unit, I first introduced a real-world context for them to see. The focus in this unit was on toxins, and I gave them a context to think about. The context was that any substance, even water, can be toxic if too much of it is consumed.

Once the context was introduced I expanded on the idea. I talked to the students about snake venom. We discussed as a class how snake venom is very toxic and can be deadly, especially for small children and small animals. We then discussed how tiny amounts of snake venom have been used therapeutically as a medicine to control high blood

pressure. I then asked the students a question: How much is too much of a substance and to explain their answer? I then followed with the question: How are amounts of substances measured and to explain their answer?

After the introduction of the real-world context, I then started to discuss the concepts involved in stoichiometry, each time we related the concept to toxins. The first step was talking about how toxicity is measured. The students learned determine a lethal dose of a toxic in relationship to body weight. They worked on the exercises found in Appendix C. After finishing the exercises, they started on the activity in Appendix D in which the idea of moles was introduced. Once the idea of moles was introduced the students' then looked at calculating the amount of carbon dioxide in the activity found in Appendix E. To finish the unit, students worked on the lab involving real world contexts of stoichiometry in food found in Appendix F.

In the second treatment unit, the students studied solutions. I started out with a context that was very familiar to the students, that being sports drinks. I had an article about sports drinks for the students to read called "Don't sweat the small stuff" from the *ChemMatters* magazine. Once they read the article, we discussed the concepts used in solutions. The students then practiced the concepts in solutions in labs found in Appendices G and H. These labs deal with molarity in which the students have to determine the molarity of Kool-Aid and also solve a murder mystery.

Data Collection Instructions

McCook High School is a rural southwest Nebraska high school. The school is located in the city of McCook, Nebraska. McCook has a population of around 7,000 people. The city is dependent on industry and agriculture. The overall population of the high school

was approximately 400 students. These students were mostly White and come from middle-class families. The school has around a 5% Hispanic population. For the action research project, I chose to use my regular chemistry classes. Together these classes have a total of 74 students. There was a wide range of backgrounds in these three classes but they encompass the main demographic of the school. The majority of the students in these classes were of an average academic ability. The ratio of male students to female students was approximately 1:1.

The students in these classes have typically been together in the same classes for the last six years. They were usually very comfortable with each other. However, this also tends to lead to a small percentage of the students just looking to pass the class. This percentage is not very motivated to learn and have a tendency to rely heavily on their classmates to get them through. The rest of the students are reasonability motivated; they have goals of going to college and view the course material as something they need to learn.

Instruction and data collection for the nontreatment unit took place over 2.5 weeks. The two treatments unit's instruction and data collection took place over 2.5 weeks. The project ran a total of 8.5 weeks. A timeframe for the project is provided in Appendix I. The triangulation matrix shown in Table 1 summarizes the three data sources that will be used for each question. The triangulation of the data helped to provide both quantitative and qualitative data regarding the effects of the invention. Data were collected from both nontreatment and treatment units to be used for comparison.

Table 1
Triangulation Matrix

Focus Questions	Data Source 1	2	3
Effects on understanding	Pre and Postunit student assessments	Pre and Postunit student interviews with concept questions	Pre and posttreatment student surveys
Effects on long-term memory	Postunit and delayed student assessments	Postunit and delayed student interviews with concept questions	Posttreatment and delayed student surveys
Students' motivation and attitudes	Field observations	Pre and Postunit student interviews with concept questions	Pre and posttreatment student surveys
My teaching and attitudes	Teacher weekly reflection journals with prompts	Pre and posttreatment teacher surveys	Nontreatment and treatment observations by colleagues with prompts

To determine the effects of using real-world contexts on the understanding and long-term memory of chemistry concepts, I collected data using concept questions, surveys, and journals at the beginning and end of all four units. The use of a pre and postunit assessment and concept interview data in all units allowed for the comparison of the percent change in student understanding. A delayed assessment was given 14 days after the postassessment. The postassessment was compared to the delayed assessment to determine long-term memory. The assessments are found in Appendix J.

The interviews were conducted in the mornings before school. The interviews were taken both before and after completion of each unit. The students were picked by their academic ability. I chose three students from high, middle, low-performing groups. The same students were used for all interviews. When the students came in for the interviews, I gave them a piece of scratch paper to use for their concept questions. I then asked the student each question and made notes of their answers.

The effects of real-world contexts on student motivation and attitudes were assessed using surveys and field observations. The use of both student perception and my own observations provided a good representation of student motivation and attitudes. By considering perspectives, data, and outliers, student responses that were disingenuous could be potentially identified.

The concept interviews were conducted before and after completion of the project in order to gauge student motivation,attitudes and understanding. The interview questions are found in Appendix K.

Surveys were given to all students upon completion of each unit. A copy of the survey can be found in Appendix L. Some questions were designed to measure motivation and attitudes alone and in conjunction with the real-world contexts.

To determine how the use of real-world contexts impacted my teaching and attitudes, I used journaling, self-evaluations, and a peer observer. I recorded my reflections after each period using the prompt in Appendix M. I also completed a self-evaluation survey, which is located in Appendix N. I had a peer observer evaluate me four times, once during the nontreament unit and once during each of the treatment units. I had them use the observation guide found in Appendix O. These evaluations gave me an understanding of how different teaching strategies impacted my teaching and attitude.

The data collected in this study were both qualitative and quantitative in nature. The qualitative data were used to determine overall trends and patterns. The quantitative data were used to measure the change in student understanding, using the pre and postunit assessments. Collecting data from both units was important in helping to determine the effects of the intervention.

DATA AND ANALYSIS

During my capstone project, I collected data during nontreatment and treatment units to determine the effect of using real-world contexts on the understanding of chemistry concepts. The data were collected using the various methods in accordance with the triangulation matrix and the results will be discussed in detail.

The data collected from the pre and postassessments allowed calculations of the percent change in understanding of concepts during the nontreatment and treatments units. The assessments used consisted of five short-answer questions. The average scores and percent change can be found in Table 2. Overall, the students showed gains in all of the units, although the data showed a larger gain in scores during both treatment units.

Table 2
Average Scores of Unit Pre-assessments and Post-assessments

Unit Data	Nontreatment Unit	Treatment Unit 1	Treatment Unit 2
Preassessment	6.8	3.4	4.7
Postassessment	10.8	9.3	11.6
Percent Change (%)	59	174	147
Normalized Gain	.49	.51	.67

Note. All assessments out of 15 points. $N = 65$.

In looking at the preassessments for each unit, it was very apparent the students had more of a background with the material in the nontreatment unit versus both treatment units. The nontreatment unit dealt with chemical reactions which they had discussed briefly in science their freshman year. In both treatment units the students had no prior background knowledge leading to lower preassessment scores. The students made gains during all three units as seen in the change in scores from the preassessment and the postassessment scores. When comparing the all three units, both treatment units showed higher gains than the nontreatment unit. The gains shown in the treatment units suggest a positive response to the instructional strategy. It appears that the type of activities used during the treatment units allowed for the students to make more of a direct connection with the chemistry concepts. The students' ability to make connections to activities in their everyday lives allowed for them to have a better understanding of the material presented during class.

Data were also collected to determine the effects of real-world contexts on understanding of chemistry concepts through student concept interviews. The concept interviews consisted of two short answer questions relating to concepts in each of the units,

along with questions asking about making connections outside of class to chemistry. These results from the concept questions are found in Table 3.

Table 3
Average Scores of Preunit and Postunit Concept Interviews

Concept Interview with different students	Nontreatment Unit Preunit	Nontreatment Unit Postunit	Treatment Unit 1 Preunit	Treatment Unit 1 Postunit	Treatment Unit 2 Preunit	Treatment Unit 2 Postunit
High-achieving 1	3	6	3	6	2	5
High-achieving 2	3	6	2	6	3	6
AVERAGE High-achieving	3	6	2.5	6	2.5	5.5
Average-achieving 1	3	5	2	6	2	5
Average-achieving 2	2	5	2	4	2	5
AVERAGE Average-achieving	2.5	5	2	5	2	5
Low-achieving 1	2	5	1	4	1	4
Low-achieving 2	2	4	1	3	2	5
AVERAGE Low-achieving	2	4.5	1	3.5	1.5	4.5
Average Preunit	2.5		1.8		2	
Average Postunit	5.2		4.8		5	
Percent Change	108		167		150	
Normalized Gain Score	.77		.71		.75	

Note. All interviews scored out of 6 points. $N = 6$.

The data from the interviews support the analysis of student understanding from the pre and postassessments. There was a greater increase in percentage change in understanding between pre and postunit assessments of the treatment units compared to the nontreatment

unit but not in normalized gain, which could be due to the lower preassessment scores for the treatment units. In looking at the percent change there seemed to be a direct relationship between using real-world contexts and their understanding of content. The low-achieving students showed the most improvement in the last treatment unit. The growth shown by the individual student's seemed to be related to their class participation.

In previous years if I discussed sports drinks my students' basic response was that they "taste better than water". There was no real understanding as to how and why the sports drink worked in your system. During the interviews after the treatment for solutions the students were able to discuss why sports drinks were used to rehydrate our bodies when exercising. The more involved the student was during class, the better their explanation of concepts during the interview process. This trend was seen even with the low-achieving student. The average score for the low-achieving students showed an increase. In the final treatment unit the low-achieving students had an increase in their scores of 3. The overall, comfort level in the low-achieving students' discussion was very evident when talking with them.

After completing the concept questions, the students were asked to make connections to chemistry outside of class. During the nontreatment unit, the students struggled with giving me any connections of chemical reactions to their everyday lives. This was very evident in both the preunit and postunit responses. They also could not give specifics in how to balance or decide the type and products of a reaction. The students, however, were quickly able to balance the equation in the postunit interview.

In the first treatment unit on stoichiometry, there appeared a noticeable difference in the student's ability to explain the process and connections to their everyday lives as compared to their explanations during the nontreatment unit interviews. During the

nontreatment units the students, especially the low-achieving students, struggled with explaining how to work the problem. They kept guessing and giving random answers in an attempt to find the right one. In the treatment unit interviews the preunit interview all of the students had difficulty with the content questions and explaining how to solve the stoichiometry problem. When doing the postunit interview, the low-achieving student was able to tell me the conversion factors needed to accomplish the concept questions with little to no difficulty. All of the students interviewed were able to discuss connections during the postunit interviews. During the interviews for the first treatment, the students were able to relate ideas in stoichiometry to a working airbag. The students were all able to discuss the amount of reactants and products and controlled how well an airbag worked.

By the second treatment unit on solutions, the students had more experience with the concept of solutions that were studied in the previous units. They scored higher on the concept questions because of an increase in their knowledge from the previous unit. However, their ability to answer the concept questions correctly was shown in the large gain from the pre and postunit scores. During the postunit interview, the students were better able explain the process for solving the problems without having to look at their work in the scratch paper. The students appeared overall to understand the concepts just made a few small calculation errors. One student was quoted as “freshman year during the chemistry, I didn’t understand anything and kept failing my tests. This year I’m pretty confident and understand the material more than I ever did”. Due to the cumulative nature of concepts, it is not obvious if the gains in understanding are related to the intervention.

Data were also gathered from pre and post unit surveys given to all the students. The survey asked the students questions about how well they felt the understood the material presented in each of the units. Students were asked what they felt about the material and

their level of understanding. The responses in general were very similar in nontreatment and treatment unit in their response to the type of activities used during class. In all classes the students preferred lab work over typical homework problems. They felt the labs helped them to understand the material better. The students admitted in the surveys during the treatment units an increased understanding of material. The data in Figure 1 showed an average Likert score of 3.1 for the nontreatment unit and scores of 4.2 and 4.3 for the treatment units for the level of understanding. The scores showed an improvement in their level of understanding. The majority of the comments from students felt they were more confident in their understanding. One said, "I've learned things I didn't even know about chemistry and how things in real life are related to chemistry."

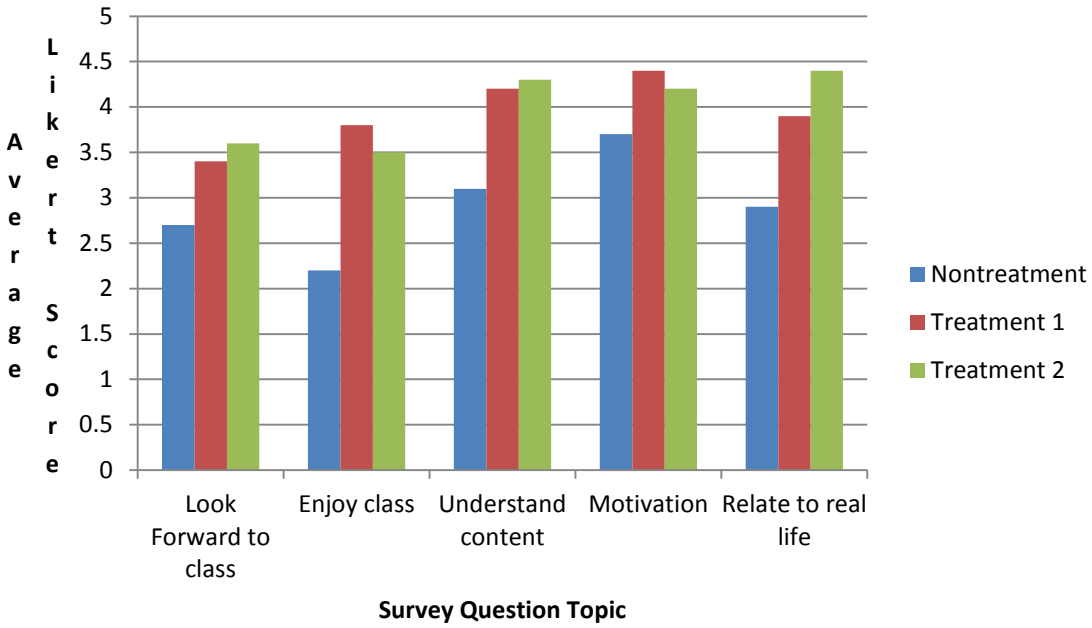

Figure 1. Average student survey response for 5 questions on students motivation and perception of understanding (*N*=65). *Note*. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

In addition to determining if using real-world contexts increased understanding, I was also interested in learning if the treatment increased long-term memory. Roughly about two

weeks after each postassessment, the students were given a delayed assessment to test their long term memory. Each student was given the same five question assessment. Figure 2 shows a comparison of the average scores on the postunit assessment and the delayed assessment.

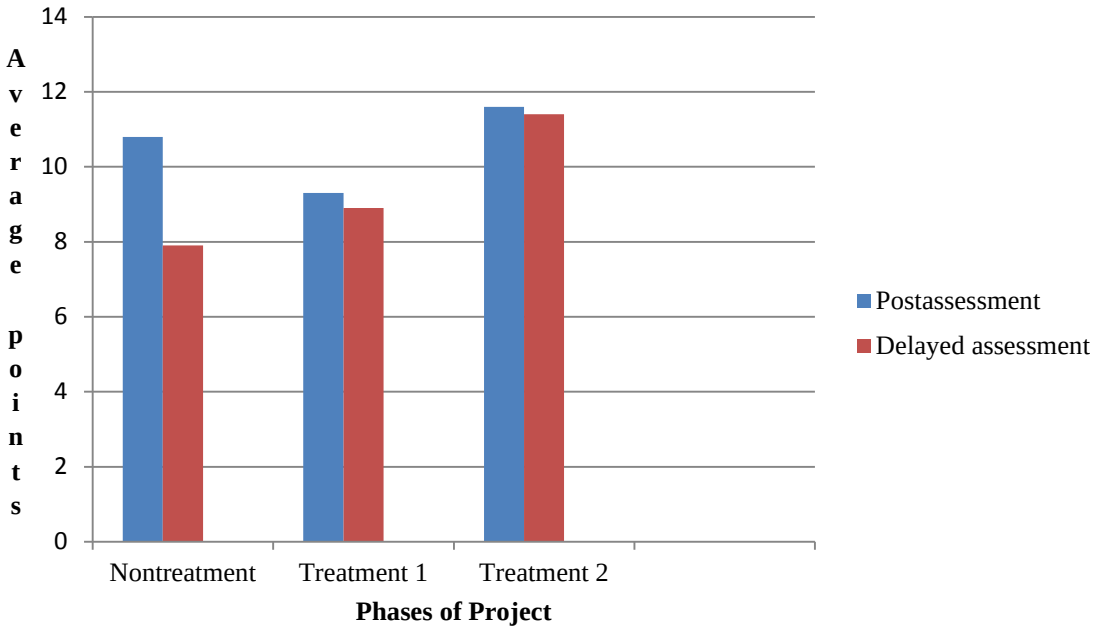

Figure 2. Average points obtained on pre and post-unit and delayed unit assessments, (*N*=65). *Note.* Out of a possible 15 points.

During the nontreatment unit there was a loss of 1.9 on the average scores. In the nontreatment there was no use of real-world contexts to allow the students to attach a concept to their everyday world. The students showed only a slight decrease in their scores for both treatment units, which suggests that the intervention helped students to remember. In both treatment units the students related the concepts to occurrences in their everyday lives. We used contexts such as making cupcakes to allow students to understand a concept such as limiting reactants. Therefore when taking the delayed assessments the students were able to recall the material because it was not linked to a context in their lives.

Postunit interviews were also given around two weeks later. During this interview students were asked the same concept questions as before. Table 4 shows comparison of how the groups of student compared. These data showed support for the use of real-world contexts for long-term memory retention. All groups of students showed less of a change during both treatment units compared to the nontreatment, indicating students remembered more content during the treatment units. In the interviews one student responded with "yeah, I'm learning quite a bit because I'm recognizing the stuff in class happening around me".

Table 4
Average Scores of Post-unit and Delayed-unit Concept Interviews

	Nontreatment		Treatment 1		Treatment 2	
	Post	Delayed	Post	Delayed	Post	Delayed
High-achieving (*N*=2)	6	4.2	6	5.2	5.5	5.1
Average-achieving (*N*=2)	5	3.3	4.5	4.2	5	4.6
Low-achieving (*N*=2)	4.5	3	3.5	3.1	4.5	4.1
Percent Change	-32		-11		-8	
Normalized gain	-2		-.36		-.35	

The data resulting from the interviews showed the use of real-world contexts had a positive effect on the relationships between concepts. Overall the students were better able to form a strong connection to something in their own lives and apply it to solving the questions. In some cases they weren't able to answer with total accuracy, but they were better able to describe their answers and the process to get their answer.

Data were obtained and analyzed through the use of student surveys to help determine the effect of the treatment on student motivation and attitude. Students were asked to take a survey before treatment and after in order to gauge their attitude and motivation in class. Figure 3 shows a comparison of scores from the student surveys. The students appeared to

look more forward to the lessons and enjoy them after the treatment. There also seemed to be a gain in their level of understanding of the material. Overall, they felt more comfortable with class in general after treatment units.

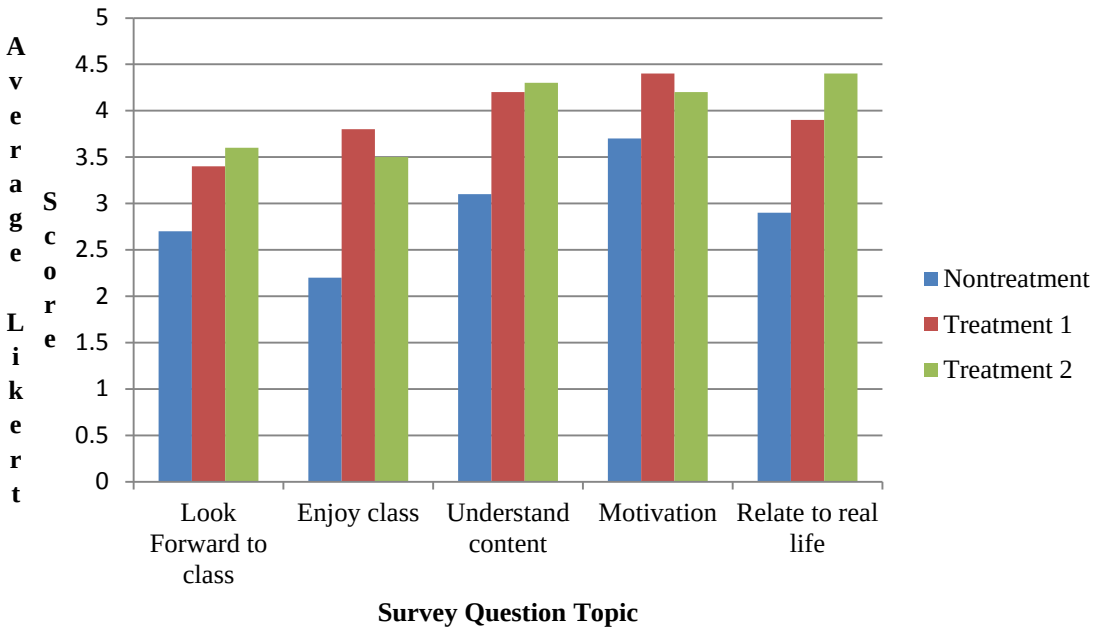

Figure 3. Average student survey response for 5 questions on students motivation and perception of understanding (*N*=65). *Note*. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

On the survey, students had a few questions that pertained to their attitudes and understanding of science. The majority of students felt they were ultimately more comfortable after the use of the treatment. One student responded on their survey with "Yes, I've learned things I didn't even know about chemistry and how things in life are related to chemistry".

A piece of data that supported an increase in student attitude was shown in the increase on the survey. Students were asked how much they enjoyed the lessons and how hard they worked. Overall, the ratings were higher after both treatment units.

In interviewing the students before and after the treatment, the general theme showed an increase in a positive attitude toward science. A student in the interview responded to one question with the following comment, “I do learn a lot in chemistry! I use it in my everyday life and I notice it when friends or family mention something or ask about something I’ve learned, I’m always right”.

During the nontreatment unit, observations were made about how engaged students’ were in class. Students in the nontreatment appeared to be most engaged during labs primarily. During the discussion time of the nontreatment the students appeared to be concerned only with writing down the material. However, observations during the both treatment units showed an increase in student engagement. Students were more active in discussions of content, as well as asking more questions about material. Figure 4 shows a comparison of engagement and interaction scores by the observer.

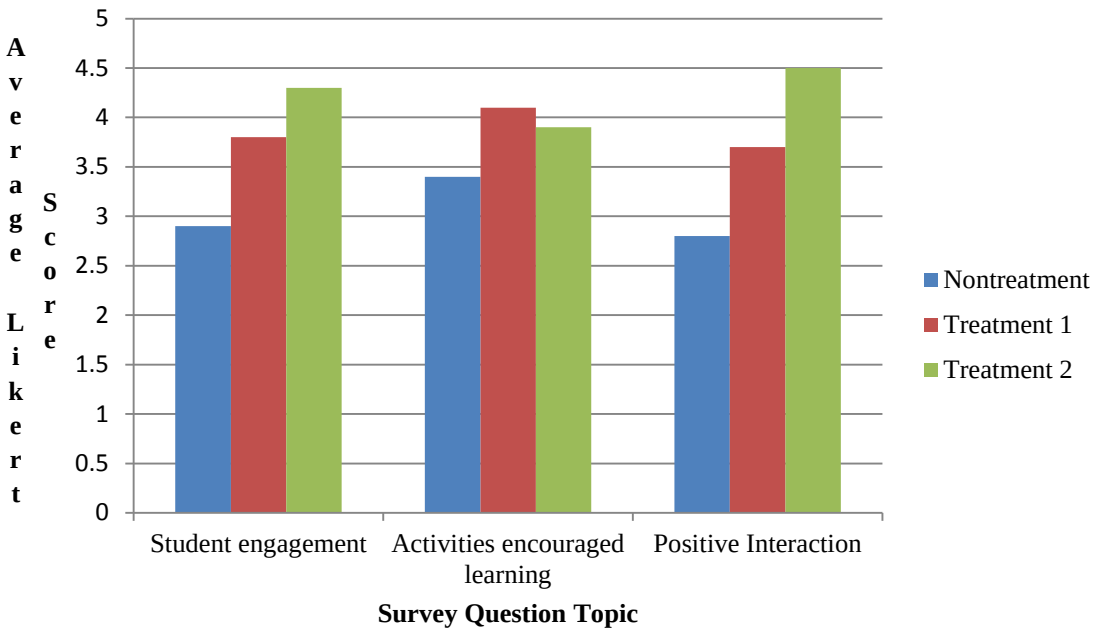

Figure 4. Peer observations of student engagement, (*N*=65). *Note*. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

The final question I wanted to address in this project was the effect of using real-world contexts on teacher attitude and motivation. Data were collected using a teacher survey, teacher journal, and observations. During the units I took a daily survey, I also completed a journal entry after each week. Figure 5 shows a nontreatment versus treatment unit comparison of scores from teacher survey.

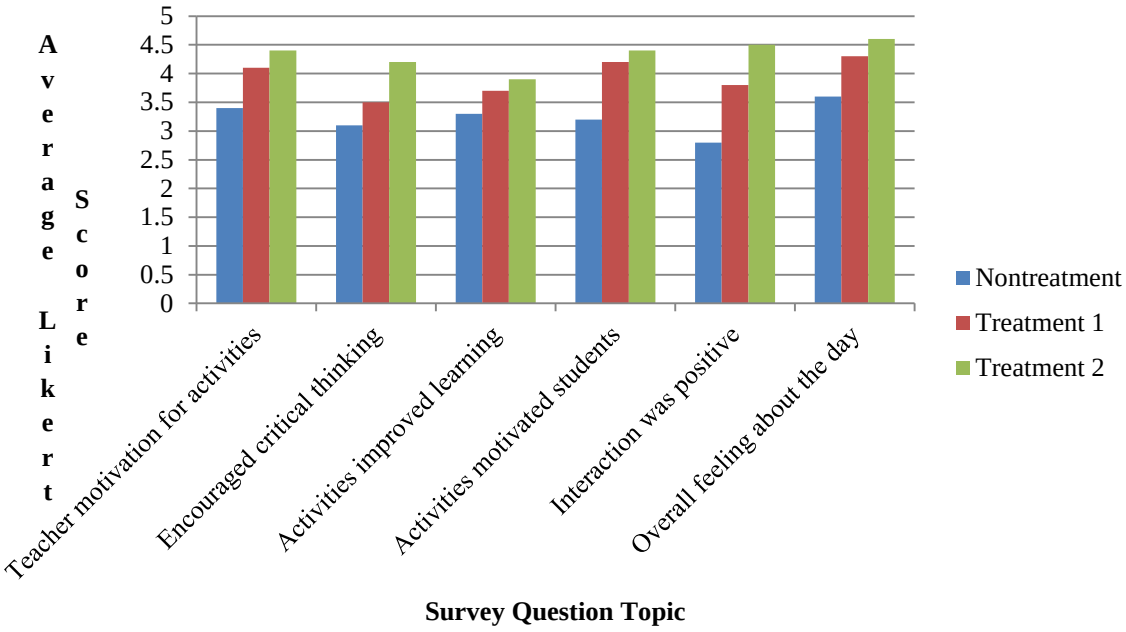

Figure 5. Average teacher survey response for 6 questions on self evaluation. *Note*. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

Overall, the use of real-world contexts had the largest effect on my motivation for class. The developing of activities to use for the contexts was a little more time consuming than traditional methods. However, the increase in classroom participation was a nice response to the extra time. In my journal, I noted that I felt less frustrated several times throughout the treatment units in comparison to the nontreatment unit.

The survey showed positive changes on my perception of the lessons and how the students received them. The use of real-world contexts had an increase on my motivation, encouragement of critical thinking, student learning, positive interaction, and the overall

feeling of the lesson. The most noticeable change was the students' interest in discussing the contexts and material. In some cases the students may not have fully understood the concepts in order to show them on paper but they could talk about the material after the treatment. The responses in the interviews allowed me to develop higher-level questions to ask during class. The increases in student engagement lead to an increase in my feelings toward class. I felt more positive about each lesson and how the students were learning.

At the end of each unit, I looked at the peer observations done. I used the data to track my attitudes and motivations towards using real-world contexts. As seen in Figure 6 there was a slight increase in my attitude, engagement, and motivation. The peer observer made a comment during one of the treatment observations that I appeared much more relaxed and upbeat in class. Even though the peer observer noticed mostly slight changes in my attitude, I felt my attitude becoming more positive and my motivation increase.

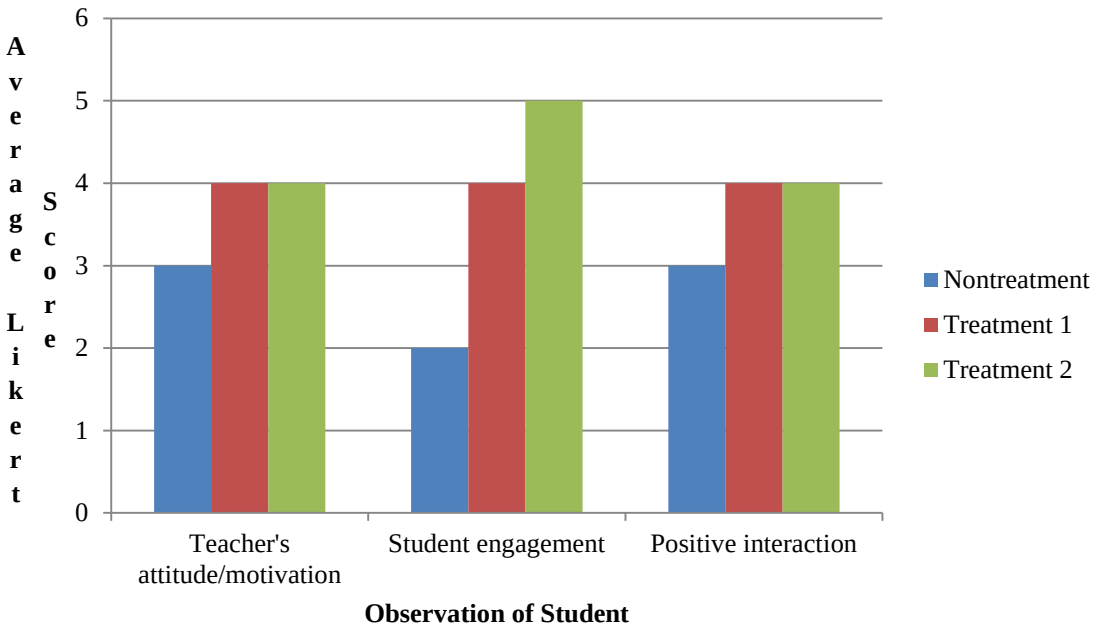

Figure 6. Average teacher response for field notes question on students on task. *Note*. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Agree.

INTERPRETATION AND CONCLUSION

The goal of this capstone was to determine the effects of real-world contexts on the understanding of chemistry concepts. In looking at data from both assessments and interviews it showed an increase during each treatment unit. In this regard the real-world contexts seemed to have a positive effect on the understanding of my students. The survey data also showed an increase in almost all areas by the end of the second treatment unit. These data suggest that the use of real-world contexts had a positive impact on the understanding of chemistry concepts.

I also wanted to look at some deeper effects of real-world contexts with this project. I first wanted to look at how real-world contexts affected the long-term memory of my students. The data showed that during the treatment units there was a smaller decrease in the scores on the delayed assessments when compared to nontreatment delayed assessment. The survey and interview data also showed that the students felt they remembered the concepts better after treatment. Therefore, real-world contexts appeared to have a positive effect on the students' long-term memory in that they seemed to remember more concepts better with treatment.

The next goal of the project was to see the effect on students' attitude and motivation toward chemistry. The data from all three sources, survey, interview, and observation, showed a slight increase in the attitudes and motivation of the students from the nontreatment unit to each treatment unit. In most responses as earlier stated the students felt more comfortable with the concepts, thus improving their attitudes.

The final goal of the project was to determine the effect of real-world contexts on the teacher's attitudes and motivation. In looking at data collected from journal entries, survey, and peer observation it showed that there was a positive impact on my attitude and

motivation. My attitude and motivation saw a small increase with the first treatment and again with the second treatment.

This data suggest that using real-world contexts had a positive effect on the understanding of chemistry concepts. However, there are some changes I would make to improve the project. The first improvement, I would make is to alter some of the survey and interview questions. Instead of asking students if they looked forward to coming to class during the two weeks, I would change the question to specifically ask if their attitude towards class changed over the two weeks. I think asking if they looked forward to class is slightly vague and other factors could enter into them answering that survey question. I would also include a couple more specific concept questions on the student interview to look closer at the effects of real-world contexts on understanding and long-term memory. Finally, it would be beneficial to conduct this project at the beginning of the school year when the students' prior knowledge is more limited. The students in this project had already been in class for a semester and probably developed opinions of class in general. Using the same treatment at the beginning of the year might contribute to give a more accurate picture of the effect of using real-world contexts.

VALUE

For most students learning chemistry is a difficult task. Many students have never been exposed to the concepts or even thought about how chemistry affects their lives. This project has allowed me to see how using real-world contexts can positively affect students' understanding of chemistry concepts. The results helped to show me and my students the benefit of relating things to everyday life and its uses. The results show that the traditional method of teaching science may not be the best for students in today's classrooms. The

study has lead me to consider changing how I group material and teach it in my chemistry classes.

The results of this project are not limited to just the chemistry classroom. In all areas, teachers hear the same old comment, “when will I ever use this”. The ability to understand and remember content is crucial to student success in the classroom. In a math class, using real-world contexts such as determining the cause of an accident to teach trigonometry skills gives the student a purpose for the information. A student who sees a purpose to the material is generally more successful in the classroom.

I think this project was beneficial for my students for two reasons. First, they were able to make connections to their lives which lead to a better understanding. Second, they retained the information better, since chemistry builds on prior knowledge. The students ultimately become more successful because they have a better grasp of the content.

This study also has changed my thoughts as a teacher. Often as a teacher, I get into a routine that is comfortable. Teachers also tend to teach the way we learn best, which is not always right for our students. I have learned to be more reflective in my teaching. When I take the time to reflect, I am better able to decide if a lesson was effective. This allows me to develop more effective lessons and improve the ineffective. The study also forced me to think about what affects my students’ understanding. By knowing what improves their understanding, I can better help my students. I also learned several things about myself. During the study I noticed the more actively involved in discussions the students were the more motivated I was. There also seemed to be a direct correlation in my students’ attitudes and mine in class.

Working on this capstone has definitely motivated me to work during this coming summer to make changes in within my classroom. I hope to flip my classroom and bring in

more real-world contexts so more class time can be spent on discussions and interacting with the students. I think over time I forgot that sometimes the subject that excites me doesn't always excite my students, and I need to use things to bring them into enjoying the class. Being able to spend time working on this capstone has helped me developed new ideas.

Overall, I think the most challenging part of this project was just keeping up. Once the data started to come in, it began to get a little overwhelming. I struggled a little with making sure I stayed on top of everything for the capstone and my other classes. However, the project has definitely changed my attitude toward teaching and the lessons learned during the capstone will help me to develop better lessons with the 165 students I anticipate having next school year.

This capstone gave me insight on my students' that will have an effect on my teaching next year and in the years to come. Most importantly I have learned to be more reflective in my teaching. It is important to not only identify what is effective but to determine why some content is typically more difficult for students. However, understanding what makes a more effective teacher is always a goal of action research.

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APPENDICES

APPENDIX A

CHEMICAL REACTIONS WORKSHEET NONTREATMENT UNIT

Six Types of Chemical Reaction Worksheet

Balance the following reactions and indicate which of the six types of chemical reaction are being represented:

1) ____ $NaBr$ + ____ $Ca(OH)_2$ → ___ $CaBr_2$ + ____ $NaOH$

Type of reaction: _____

2) ____ NH_3+ ____ H_2SO_4 → ____ $(NH_4)_2SO_4$

Type of reaction: _____

3) ____ C_5H_9O + ____ O_2 → ____ CO_2 + ____ H_2O

Type of reaction: _____

4) ____ Pb + ____ H_3PO_4 → ____ H_2 + ____ $Pb_3(PO_4)_2$

Type of reaction: _____

5) ____ Li_3N + ____ NH_4NO_3 → ___ $LiNO_3$ + ___ $(NH_4)_3N$

Type of reaction: _____

6) ____ HBr + ___ $Al(OH)_3$ → ___ H_2O + ___ $AlBr_3$

Type of reaction: _____

7) What's the main difference between a double displacement reaction and an acid-base reaction?

8) Combustion reactions always result in the formation of water. What other types of chemical reaction may result in the formation of water? Write examples of these reactions on the opposite side of this paper.

APPENDIX B

TYPES OF CHEMICAL REACTIONS LAB NONTEATMENT

Types of Chemical Reactions

Safety

1. Use precaution when lightening and operating the gas burner. Make sure to point the test tube away from yourself and other.
2. Do NOT look directly at the burning magnesium.
3. 6M hydrochloric acid can cause burns to the skin and damage

Pre-Lab Predictions

For each reaction specify the types of reaction and predict the products that will form. Be sure to balance the each equation.

A. $CaF_2 + Na_2CO_3 \rightarrow$

B. $Mg + HCl \rightarrow$

C. $CuCO_3 \rightarrow$ Carbonates break down to form CO_2 and a metal oxide

D. $Mg + O_2 \rightarrow$

Procedure

Reaction A

1. Add about 1 mL of calcium chloride solution, to a clean test tube. Next, add about 1 mL of sodium carbonate solution, to the same test tube. Record results in a data table.

Reaction B

1. Stand a clean test tube in the test tube rack and add 1-2 mL of 6M hydrochloric acid. Carefully drop a few pieces of magnesium into test tube.
2. While the reaction is still occurring, use a test holder to hold empty test tube over the top of the first for 30 sec. Light a wooden splint with a match, at the end of the 30 sec hold the inverted test tube (keep it inverted). Place the wooden splint into the mouth of the inverted test tube to test for the presence of hydrogen gas.
3. Record the results on the data table.

Reaction C

1. Place 2 spoons of copper(II) carbonate, in a clean test tube. Note the appearance of the sample.
2. Using a test tube holder, heat the $CuCO_3$, strongly in the burner flame for 2-3 min. After heating, ignite a wooden splint and quickly place the burning splint into the test tube to test for CO_2.

3. Record your results in your data table.

Reaction D

1. Place a watch glass next to the burner. Using crucible tongs, hold the ribbon in the burner flame until the magnesium starts burn. DO NOT LOOK DIRECTLY AT THE FLAME. Hold the burning magnesium directly over the watch glass. Record the results in your data table.
2. Clean your test tubes and lab station. Wash any liquids down the drain and wrap solids in paper towel before discarding them in the trash can.

Conclusions

Write conclusion for the lab based on your results.

This lab was developed by Northside Independent School District Science teacher, Christy Johannesson

APPENDIX C

TOXINS EXERCISES TREATMENT UNIT 1

TOXINS

Measuring Toxins Exercises

1. How can scientists determine the toxicity of a substance?

2. How is toxicity related to body weight?

3. Find at least five products at home with labels that warn of toxicity. For each product, give the name the product, and answer these questions?

    a. How does each label advise you to avoid harmful exposure to the product?
    b. What does each label tell you to do if a dangerous exposure does occur?
    c. Using all this information, what can you hypothesize about the chemical properties of each product?
    d. Look at the recommended treatment for dangerous exposure to the product. What chemical and physical processes do you think might be involved in the treatment?

4. Ethanol is grain alcohol. The LD_{50} for ethanol is 7060 mg/kg (rat, oral).

    a. How many milligrams of ethanol would be lethal to a 132 lb adult?
    b. How many glasses containing 13,000 mg of ethanol would be lethal to a 22 lb child?

5. The LD_{50} for vitamin A is 1510 mg/kg (rat,oral).

    a. How many mg of vitamin A would be lethal to a 132 lb adult?
    b. How many vitamin tablets containing .40 mg of vitamin A would be lethal to an adult?

APPENDIX D

ACTIVITY: COUNTING BY WEIGHING TREATMENT UNIT 1

ACTIVITY

Counting by Weighing

Purpose: To count large numbers of small objects by weighing.

Procedure:

1. Obtain a sandwich bag from your teacher. Your bag may contain items such as rice, beans, or paper clips.

2. Your challenge is to determine the number of objects in your bag without opening it.

3. Brainstorm how you will solve the challenge with the members of your group and decide what tools you might use.

Questions:

1. Describe the method you are going to use to determine the number of objects you have in your bag. Be specific.

2. Find out what other substances are in the sandwich bags of the other groups. Make a list of all the substances.

3. Which of the substances' counts do you think will be the easiest to determine? Explain your reasoning.

4. **Making Sense** What do you think this activity has to do with keeping track of chemical compounds?

5. **If You Finish Early** Are 100 molecules of snake venom equivalent in toxicity to 100 atoms of arsenic? Why or why not?

This lab was developed based from Stacy, *Living By Chemistry*, copyright 2012.

APPENDIX E

CARBON DIOXIDE PROBLEM TREATMENT UNIT

Carbon Dioxide Problem Treatment Unit

In the movie "Apollo 13" there was an example of stoichiometry and problem solving in action. As a result, of the accident the crew was forced to "re-breathe" the cabin air. The problem you are asked to consider is the fact that air breathed over and over again in a confined space becomes lower in oxygen and higher in carbon dioxide. The carbon dioxide levels can become toxic, and the crew can asphyxiate.

Excess carbon dioxide can be absorbed or "scrubbed" from the air by a strong, solid base like lithium hydroxide.

Questions about Apollo 13's lunar mission.

1. What are the formulas for carbon dioxide and lithium hydroxide?

2. What is the balanced equation for the reaction of these 2 chemical compounds?

3. What phase (physical form) will the product(s) be in when the reaction is complete?

Human tidal volume during normal quiet respiration is about 500 mL for an adult. Total respiratory volume for an adult male is about 6000 mL. Under the respiratory distress of increasing carbon dioxide, tidal volume may increase to as much as 3000 mL. For this problem let's use an average of 1400 mL for the tidal volume each of the **three** Apollo 13 astronauts.

Resting respiratory rate for adults is 12-18 breaths per minute (bpm). Under stressful conditions, we would expect to be at the high end of that, so let's use 18 bpm for our problem.

For a human adult breathing normal air, inhaled air is about 0.04% or 0.3 mm Hg partial pressure carbon dioxide. Exhaled air is approximately 5.2% or 40 mm Hg partial pressure carbon dioxide. The density of normal air is about 1.2g/L.

4. Using the information given so far, calculate the number of grams of carbon dioxide exhaled in each breath (not counting what was inhaled.)

5. What mass of carbon dioxide did all 3 astronauts exhale over a 5-day period?

6. What mass of lithium hydroxide would be required to react with (absorb) **all** the carbon dioxide exhaled by the astronauts over 5 days?

7. If the toxic level of carbon dioxide were 15 mm Hg, what would have been the minimum mass of lithium hydroxide necessary to keep the astronauts alive.

This activity was developed from the Journal of Chemical Education.

APPENDIX F

CUPCAKE LAB TREATMENT UNIT

Cupcake Lab Treatment

The Stoichiometry of Cooking

Instructions
Follow the instructions and make your own cupcakes. Make sure that you know the variation in your recipe.

Before You Bake
When you bake at home you use measuring cups. Here, you weigh the ingredients in grams.Why? What can you learn from the gram weight of the ingredients?

Pour a little batter into a plastic cup and measure its pH:

Is the batter acidic or basic? Why?

Easy Cupcakes

What You will Need:
• 240 g (1 cup) sifted flour
• 180 g (3/4 cup) sugar
• 10 g (2 teaspoons) baking powder
• 60 ml (1/4 cup) shortening
• 5 g (1/4 teaspoon) salt
• 120 ml (1/2 cup) milk
• 2.5 ml (1/2 teaspoon) vanilla
• 2 eggs
• Favorite frosting

Recipe:
1. Preheat the oven to 350 degrees Fahrenheit.
2. Sift all dry ingredients and set aside.
3. Measure all liquid ingredients, and combine in a separate container.
4. Combine dry and wet ingredients in a large mixing bowl.
5. Blend for 1/2 minute on low speed, scraping the sides of the bowl constantly.
6. Beat an additional three minutes on high speed, again scraping the bowl occasionally.
7. Place cupcake papers in muffin tins, and pour the batter into the cups, filling them halfway up to the top.
8. Bake for 20-25 minutes.
9. Cover with favorite frosting after it cools.

After You Bake

Fill in the following table about properties of the cake:
Property Description
Moisture
Texture

Consistency
Height
Taste

Summary
Define stoichiometry:

How does baking stoichiometry affect your cake product?

This lab was developed by Lisa Morine.

APPENDIX G

KOOL-AID LAB TREATMENT UNIT 2

Molarity of a Solution

A cool aid to chemistry.

PURPOSE: The purpose of this activity is to:

1. Calculate the amount of solute needed to make a specific molarity of a solution. Using these calculations, each solution will be made.

2. Calculate and then dilute a concentrated solution to obtain a new molarity.

DISCUSSION:
To calculate the amount needed of a solute needed, the gram formula mass of the solute must be given or calculated. By rearranging the formula: Molarity = moles of solute/volume of solution, the following equation is obtained: Molarity x volume of solution (in liters) = moles of solute. Using the gram formula mass of the substance, the amount of substance can be calculated in grams.

When a solution is prepared in the lab, a volumetric flask is used. A volumetric flask is a special flask that has been calibrated to hold a specific amount of solution.

TO PREPARE A SOLUTION: the amount of solute needed is calculated and then obtained. The solute is placed in the volumetric flask. The flask has a mark on the neck of the bottle. Water is then added to this mark, reading the bottom of the meniscus. The top is then placed on the flask, and the solution is agitated to obtain a homogeneous mixture. Then the concentration of the solution is recorded on the bottle along with the symbol of the solute. The symbol M represents molarity, the concentration equal to the number of moles of solute contained in 1 liter of the solution.

EXAMPLE:

250 mL of a 2.0M NaOH solution is desired. How would this be prepared?
Molarity x volume (in liters) = moles of solute
2.0M NaOH = 2.0 moles NaOH/liter of solution 250 mL = 0.25 L
2.0 moles NaOH/liter of solution x 0.25 L = 0.50 moles NaOH
0.50 moles NaOH x 40 grams/mole NaOH = 20. grams NaOH

To prepare 250 mL of a 2.0M NaOH solution: Obtain 20. grams of NaOH and place in a 250 mL volumetric flask. Add water to the mark. Stopper and mix. The solution has the concentration of 2.0 molar. Label the bottle with 2.0M NaOH.

MATERIALS AND EQUIPMENT:

Balance	Kool-aid® (Solute) in 300 mL vial
120 mL graduated vial	concentrated juice solution
paper cups	Cold water (solvent)

SAFETY: This activity is designed to teach concentration. When mixing chemicals in the lab, the student would not normally be asked to taste a solution. In this activity, special precautions have been taken. The vials used have only been used to make Kool-aid® solutions. Special care must be taken so that the vials do not become contaminated.

Do not drink the solutions from the vial. The vial is for measuring and mixing only. **Pour the solution into a paper cup before drinking.**

Do not pour the solid Kool-aid® back into the container if you pour out too much. Dispose of the excess in the trashcan. Do not drink the water directly from the bottle.

PART 1 PREPARATION OF SOLUTIONS

DIRECTIONS:

In the first part of this activity, you will make 4 different solutions of Kool-aid®. It is not required that you taste these solutions. If you do not wish to taste the solution, give the solution to the instructor to taste.

FOR ALL EQUATIONS: 1 MOLE KOOL-AID® = 40 GRAMS

Make the following solutions. **For each solution, show all work in calculating the correct amount of solute. Do your calculations on a separate sheet of paper.** Label each paper cup with the correct concentration. After all four solutions have been prepared, taste each solution and answer the questions.

Sample #1. Make:**100.0 mL of a 2.0M Kool-aid® solution**. Do the calculations on your separate sheet of paper, then prepare the solution.
Sample #2 Make **50.0 mL of a 4.0M Kool-aid® solution.** Do calculations first, then prepare as before.
Sample #3 Make **60.0 mL of a 2.0M Kool-aid® solution**. Repeat
Sample #4 Make **70.0 mL of a 1.0M Kool-aid® solution**. Repeat.

QUESTIONS:

1. Which concentration of Kool-aid® tastes correct?

2. The first calculation for 100 mL of a 2M solution and the second calculation for 50 mL of a 4M solution came out with the same amount of solute used. Explain why the two solutions tasted differently.

3. Which of the four solutions was the most concentrated?

4. In the Kool-aid® solution, what was the solvent used?

5. In the Kool-aid® solution, what was the solute used?

This lab was developed by East Syracuse Minoa High School.

APPENDIX H

MOLARITY MURDER MYSTERY TREATMENT UNIT 2

Molarity Lab – Murder Investigation

BACKGROUND:

You are going to use your knowledge of chemical reactions to be a forensic scientist and solve the murder of Miss Scarlet. Beside her body police found a clear liquid, undoubtedly the murder weapon. It was determined that the murder weapon was one of two chemicals. They knew that Miss Scarlet was allergic to potassium iodide, and that there was widespread use of silver nitrate, which is toxic if ingested, by several members of the household. Police further discovered the following evidence.

Professor Plum, an eccentric chemistry teacher, was working in the *study* with silver nitrate solutions of molarities 0.20 to 0.30. Miss Scarlet was Plum's worst student, arriving to class late, being responsible for lots of broken glassware, and rarely cleaning up after her experiments.

Mrs. White, an asthmatic, has a prescription for potassium iodide. The pharmacist assured us that her potassium iodide solution has a molarity in the range of 0.05 M to 0.15 M.

Mr. Green, a photographer, had solutions of silver nitrate between 0.05 M and 0.15 M in the darkroom. Mr. Green apparently had been caught scarlet-handed at his own blackmail game.

Mrs. Peacock, wearing the same dress as Miss Scarlet, was found in the stable, administering potassium iodide solution to her horse. When questioned, she admitted that her horse had a severe case of bronchitis. Her veterinarian informed detectives that the strength of the solution was greater than 0.20 M. It is likely that she knew of Miss Scarlet's violent allergy to potassium iodide, since they had been lab partners in Professor Plum's chemistry class.

Colonel Mustard, had silver nitrate solutions in excess of 0.30 M, in the conservatory. The Colonel, who despised the left-wing politics of Miss Scarlet, enjoyed his leisure hours making explosives.

YOUR TASK:

You can obtain a sample of the murder weapon found at Miss Scarlet's side by asking your teacher for it, in the classroom. If you can determine whether it is silver nitrate or potassium iodide, then you can narrow the list of suspects considerably. And if you can determine the molarity of the unknown solution, then you can solve the case.

Who was the murderer? What was the murder weapon? What was its molarity? Provide a short, formal lab report giving evidence and analysis useful for the prosecution of the murderer. Your evidence will be Exhibit A at the trial, and will be subjected to the scrutiny of the defense attorney. On the basis of your evidence, a murderer might be set free or an innocent person executed.

MATERIALS AVAILABLE:

100ml of unknown solution, 0.1 M NaCl (aq), 0.1M $NaCO_3$ (aq), beakers, flasks, graduated cylinders, filters, filter paper, balances

SUGGESTED PROCEDURE:

1. Use your knowledge of double replacement reactions and solubility rules to determine how each of the possible murderous solutions would react with the known solutions provided. Perform the reactions and assess the results.
2. Once you have figured out which of the possible solutions the unknown is, use your knowledge of separation of mixtures, and the definition of molarity to determine the approximate molarity of the solution.
3. After you have determined the identity of the murderous solution and its molarity you should be able to conclude which of the suspects is the murderer and where the murder was committed in order to write up your report for the court trial.

FINAL REPORT:

The final report that you will hand in must contain the following sections:

Purpose: In one or two sentences, state what the problem is that you are trying to solve.

Materials: List the materials that you used in the lab

Procedure: List the steps that you used to determine the identity of the solution and its molarity. Be very specific so that someone could repeat what you did and get the same results. Include amounts used and types of glassware.

Data: This section should include tables with all observations made and any measurements recorded.

Calculations: Show all reaction predictions and calculations here.

Conclusions: In a short paragraph, summarize the conclusions that you have made as to the identity of the solution and its molarity, citing the lab techniques that you used to arrive at those conclusions. Finally, state who you suspect the murderer is and where the murder was committed, based on the police evidence.

This lab is adapted from “The Return of the Yellow Lab” by Bob Jacobs at Wilton High School.

APPENDIX I

PROJECT TIMELINE

Project Timeline

January 3th – Nontreatment preunit assessments
Started nontreatment preunit concept interviews
January 4th – Direct instruction on chemical reactions
January 7th – Balancing reactions
January 10th – Types of chemical reactions
January 11th – Types of chemical reactions lab
January 14th – Predicting reactions
1st observation by colleague
January 17th – Test review
January 18th – Nontreatment postunit assessment
Started nontreatment postunit concept interviews
January 21th – Stoichiometry Treatment Unit 1 preunit assessment
Start Treatment Unit 1 preunit surveys
January 21th – Introduce real-world context on Toxins
January 22th – Amount of Toxins
January 24th – Activity Measuring Toxins
January 25th – Carbon Dioxide Activity
January 28th – Cupcake Lab
2nd observation by colleague
January 29th – Nontreatment unit delayed assessment
January 31st – Test Review
February 1st – Stoichiometry Treatment Unit 1 postunit assessment
Start treatment unit 1 postunit concept interviews and surveys
February 4th – Solution Unit 2 preunit assessment
February 4th – Sports Drink article
February 7th – Kool Aid Lab
February 12th – Molarity Murder Lab
3rd observation by colleague
February 15th – Stoichiometry Treatment Unit 1 Delayed Assessment
February 18th – Test Review
February 19th – Solutions Treatment Unit 2 postunit assessments
Start treatment unit 2 postunit concept interviews and surveys
4th observation by colleague
March 5th – Solution Treatment Unit 2 Delayed Assessments

APPENDIX J

STUDENT PRE, POST, AND DELAYED ASSESSMENTS

Nontreatment Unit (chemical reactions)

1. What is the difference between a reactant and a product?
2. Balance the following chemical equation: $Fe + O_2 \rightarrow Fe_2O_3$
3. Identify the type of reaction: $CH_4 + O_2 \rightarrow CO_2 + H_2O$
4. Complete and balance the following chemical equation: $Mg + HBr \rightarrow$
5. Why is smoking not permitted near an oxygen source? What would happen if a match were struck in a room filled with oxygen?

Treatment Unit 1 (Stoichiometry)

1. Determine the molar mass of sodium chloride, **NaCl.**
2. How can you convert between moles of a substance and grams of a substance?
3. What is the mass of 5 mol of Fe_2O_3?
4. Which has more molecules 1 g of CH_4O or 1 g C_2H_6O? (Show your work)
5. If 3.0 moles of H_2 were burned in 2.0 moles of O_2, how many grams of H_2O would be produced? (Show your work to explain your answer.)

Treatment Unit 2 (Solutions)

1. What is the difference between the concentration of a solution and the volume of a solution?
2. What is the difference between solute and solvent?
3. Determine the number of moles of solute in 50 L of a .1M NaCl solution.
4. How many liters of a .5M solution do you need to get 3 mol of HCl?
5. A mass of 47 g of H_2SO_4, is dissolved in water to prepare a .5M solution. What is the volume of the solution?

APPENDIX K

STUDENT PRE, POST, AND DELAYED 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.

Nontreatment (Chemical Reactions)

1. Please balance the following equation. What did you have to think about in order to balance the equation? $KClO_3 \rightarrow KCl + O_2$
2. What are the products of a reaction between fluoride gas and aqueous magnesium iodide? How did you determine the products? What type of reaction occurred?
3. Do you look for connections to chemistry outside of class? Explain.
4. Did you feel you could relate the chemistry lessons to your real life? Please explain.
5. Is there anything else you would like to tell me about the work you did in class during this unit?

Treatment Unit 1 (Stoichiometry)

1. How many molecules are in 2 mol of $SiCl_4$?
2. How many moles are in 15 g of $C_6H_{12}O_6$?
3. Do you look for connections to chemistry outside of class? Explain.
4. Did you feel you could relate the chemistry lessons to your real life? Please explain.
5. Is there anything else you would like to tell me about the work you did in class during this unit?

Treatment Unit 2 (Solutions)

1. Determine the number of moles in 150 mL of .25M NaCl solution
2. How many grams are needed to make 50 mL of a .5M $Cu(NO_3)_2$ solution.
3. Do you look for connections to chemistry outside of class? Explain.
4. Did you feel you could relate the chemistry lessons to your real life? Please explain.
5. Is there anything else you would like to tell me about the work you did in class during this unit?

APPENDIX L

STUDENT SURVEYS

Student Survey

Please remember as students this survey is voluntary.

1. What did you learn about in chemistry during this past two weeks?

2. Think about your chemistry lessons during the last two weeks and answer the following: Rate yours answers 1 to 5 with 5 being the highest.
   a. How much did you look forward to your chemistry lessons?

      1 2 3 4 5

   b. How much did you enjoy them?

      1 2 3 4 5

   c. How hard did you work?

      1 2 3 4 5

   d. How much did you understand of what you were doing and why you were doing it?

      1 2 3 4 5

   e. Did the lessons relate to real-life?

      1 2 3 4 5

3. What activities in chemistry class help you learn best? Explain.

4. What was the best thing about chemistry the last two weeks? Why do you think this?

5. What was the worst thing about chemistry class the last two weeks? Why do you think this?

6. Do you think you are learning a lot about chemistry? Why do you think this?

APPENDIX M

WEEKLY TEACHER JOURNAL PROMPTS

1. Were students excited about class this week? Explain.
2. Were students enthusiastic participants in class this week? Explain.
3. What did students complain about this week?
4. What positive comments did students make this week?
5. What was the most satisfying aspect of class this week?
6. What was the most frustrating aspect of class this week?
7. How did students react to the teaching style (traditional or context) this week?

APPENDIX N

SELF EVALUATION

Self Evaluation

Self evaluation Date :

My motivation regarding today's activities 1 2 3 4 5
Comments:

Today's activities encouraged critical thinking 1 2 3 4 5
Comments:

Today's activities helped student's learn 1 2 3 4 5
Comments:

Today's activities motivated students to learn 1 2 3 4 5
Comments:

Student/Teacher interaction was positive 1 2 3 4 5
Comments:

Overall feel about today's lesson 1 2 3 4 5
Comments:

APPENDIX O

PEER OBSERVATIONS

Peer Observations

Peer evaluation Date:

Phase of class: beginning middle end

Teacher's attitude/motivation toward class activities 1 2 3 4 5
Comments:

Class activities encouraged critical thinking 1 2 3 4 5
Comments:

Students were engaged with the material 1 2 3 4 5
Comments:

Class activities encouraged students to learn 1 2 3 4 5
Comments:

Student/teacher interaction was positive 1 2 3 4 5
Comments:

Classroom atmosphere was conductive to learning 1 2 3 4 5
Comments: