The use of classroom demonstrations to improve high school students' ability to understand concepts in chemistry

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THE USE OF CLASSROOM DEMONSTRATIONS TO IMPROVE HIGH SCHOOL STUDENTS' ABILITY TO UNDERSTAND CONCEPTS IN CHEMISTRY

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Abstract

This study was completed to determine if implementing demonstrations in specific chapters of a high school chemistry classroom would enhance students understanding of the topics the demonstrations represented. The study consisted of five sections of college preparatory high school chemistry. The sections were made up of both male and female students. The sections were randomly broken up into two groups. Each group acted as the experimental and control at different points in the study. Four chapters were used in the study. Each group represented the control group in two chapters and the experimental group in two chapters, flip flopping with each chapter tested. Both groups were given a pre-test at the start of the chapter to assess prior knowledge. The experimental group was provided with classroom demonstrations throughout the chapter along with a standard lecture on the topics tested in the pre-test. The control group was given a standard lecture but was not shown any demonstrations throughout the chapter. Both groups were given a post-test to evaluate understanding gained at the end of the chapter.

No significant differences were observed between the control and experimental groups when comparing raw test scores. However, a consistent trend was observed suggesting that the demonstrations presented to the experimental group did have a positive effect on student understanding with those students obtaining higher learning gains than those without the demonstrations. In comparison of normalized learning gains between the control and experimental groups, a trend of increased normalized learning gain for the experimental groups was observed including statistical significance in two of the chapters tested. The data collected

was also broken down by gender with-in each chapter. No statistical significance was found in the raw scores or normalized learning gain based on gender.

Introduction and Literature Review

All too often in a typical science classroom lecture becomes the everyday routine for many teachers. This is often because teachers are lacking the time and energy along with a poor understanding of how to use different pedagogical techniques in the classroom such as demonstrations, to engage their students (Meyer et al., 2003). After teaching in the science classroom for several years, I have seen my students' eyes glaze over if all I do is lecture the whole time. I found this to be extremely frustrating because when it comes time for me to evaluate the students' understanding of concepts, they often cannot remember that I lectured on a particular concept let alone take and pass an assessment on that topic. One way I have found to keep my students attention throughout a chemistry class period is to mix science demonstrations into some of my lectures.

Demonstrations are illustrations of points in a lecture or lesson by using something other than conventional methods and/ or a visual-aid apparatus (Taylor, 1988). By presenting a concept in two different ways, students are able to see the concept at work in real life. I am not alone in my use of demonstrations. "Educators have often sought different ways to teach chemistry, and the use of demonstrations is but one of many teaching approaches adopted to enthuse students" (Erlis & Subramanaim, 2004). Another reason to consider the use of demonstrations in the classroom is for assessment. The teacher is able to ask probing questions on the topic being demonstrated and receive immediate feedback from the students. This allows a teacher to determine whether a new topic can be broached or if the one just taught needs to be revisited (Pierce & Pierce, 2007; Bowen & Phelps, 1997).

In this thesis, I tested whether through the use of student centered demonstrations in the chemistry classroom students will understand concepts more thoroughly than students in a classroom where demonstrations are not used. I focused primarily on the topics covered in four separate chapters of the *Modern Chemistry Textbook* (Davis et al., 2009). The topics in Chapter 1 where demonstrations were used included extensive vs. intensive properties, physical change vs. chemical change, basic behavior of molecules in solids vs. liquids vs. gases, and mixtures (homogenous vs. heterogenous) vs. pure substances (Davis et. al, 2009 pages 3-27). Chapter 6 from the textbook which covers topics on ionic bonding vs. covalent bonding, ionic vs. polar covalent vs. nonpolar covalent bonding, and Lewis structures was also included as well (Davis et al., 2009 pages 175-217). The final chapters used in the study were Chapter 10 with the focus on diffusion of gases, density of gases and liquids, phase diagrams and surface tension (Davis et al., 2009 pages 329-359) and Chapter 11 focusing on Boyle's Law, Charles's Law, Gay-Lussac's Law and Avogadro's Principle (Davis et al., 2009 pages 361-399).

While there is a lot of literature showing the effectiveness of demonstrations in the classroom, very little has been documented in high school settings. Most of the studies conducted show the effects of demonstrations on students in the collegiate setting. The two studies I have found that show the effectiveness of demonstrations in the high school setting are done in an all girls' school and all boys' school, respectively. I tested whether demonstrations in the science classroom are not only effective in the college setting or single-sex high school settings, but also in a high school class setting with mixed gender where chemistry is taught at the 10th and 11th grade level.

Studies of the effectiveness of demonstrations in the science classroom have been published for nearly a century. As early as the 1920's scientists were testing the use of demonstrations as an effective tool for increasing students' ability to understand concepts taught in chemistry. Knox (1936) studied four regular chemistry classes in Austin, Texas, with one class using demonstrations, one class using labs and the other classes using neither. He found those students exposed to demonstrations had a better retention of information both immediate and long-term as well as improved problem solving skills. His work in the area also led him to believe that using demonstrations allowed more adaptability for individual mental capabilities (Knox, 1936).

The process of lecture demonstrations allows the teacher to focus the attention of his students' on the chemical behavior taking place. Demonstrations are useful in increasing student's knowledge and awareness of chemical properties and activities. "In teaching and in learning chemistry, teachers and students engage in a complex series of intellectual activities. These activities can be arranged in a hierarchy which indicates their increasing complexity: 1) observing phenomena and learning facts; 2) understanding models and theories; 3) developing reasoning skills; 4) examining chemical epistemology" (Shakhashiri, 1983). Demonstrations must be carefully thought out and planned in order to enhance students' understanding. By doing this, students will observe chemical phenomena and learn chemical facts, learn how to explain observations and facts in terms of models and theories, develop both mathematical and logical thinking skills, and begin to examine the validity of fundamental chemistry along with examining the limitations of current chemistry beliefs (Shakhashiri, 1983).

It has been argued as early as the 1930's that money could be saved and better teaching would result by implementing demonstrations (Knox, 1936). A steady stream of budget cuts and shortfalls have been absorbed nationwide by schools causing teacher layoffs and increased class size (Dillon, 2011). Not to mention, with budget shortfalls comes less money to buy the necessary equipment and supplies to allow students to conduct some laboratory exercises. A demonstration will cut down on some of these costs. Laboratory safety concerns increase when facilities are not big enough to house such large groups of students as well. Demonstrations can address the equipment, facility, and monetary limitations faced by many chemistry teachers. Educators can use demonstrations to expose students to chemical properties and reactions that would otherwise be impossible because of the lack of facilities and equipment (Meyer et al., 2003).

When done correctly, demonstrations can provide meaningful interactions between students, teachers, and the world around them. Demonstrations that include thought provoking questions and in depth discussion can encourage sound scientific reasoning and produce unexpected results from the students. With the use of the right resources for demonstrations, teachers will see students "…become engaged in the processes of science, and will acquire knowledge and understanding of basic science concepts and the relevance of these to their everyday lives" (Herr & Cunningham, 1999).

Erlis and Subramaniam's (2004) research finds demonstrations help to address students with different learning needs. "When combined with traditional methods, it can be especially useful in reaching out to pupils who have higher visual spatial intelligence but not so high cognitive intelligence" (Erlis & Subramaniam, 2004). In their research, a series of

demonstrations were chosen on the unit of electrochemistry. The experimental group was presented with a demonstration based lesson on electrochemistry while the control group was taught with a non-demonstration traditional approach. Both groups consisted of 25 boys at an all-boys independent school. Evaluation of the effectiveness of demonstrations was done using two instruments designed by the authors and were validated by two high school chemistry teachers and two college chemistry teachers. The first instrument designed was a survey using a selective response format with the use of a Likert scale to construct questions that would measure the attitudes and opinions of the students. A Likert scale consists of a set of multiple choice questions where each potential choice is allocated a numeric value. This allows the user of the scale to take qualitative data and assign quantitative value statistically. The second instrument designed was a conceptually based multiple choice test on the topic of electrochemistry that consisted of 12 questions. No pre-test was given to determine general proficiency; however, a prior school-based test was used to determine the general ability of each group. A mean value was determined for each group from the school based test showing the demo group began with a slightly higher ability level than the control group. A mean score and standard deviation were used in the multiple choice post-test designed by the authors and the results showed that those in the demonstration group had a higher proficiency of electrochemistry after the class demonstration based lectures (Erlis & Subramaniam, 2004).

The study results prompted the researchers to conclude that the demonstration based experimental group did perform better on the conceptual test than did the control group; however, in their findings it was determined that the experimental group was also the slightly more proficient group in the study. Unfortunately, due to the nature of this study, the

investigators did not have the ability to randomly select which group was the control. That task was allocated to the teachers who themselves opted to pick the class with a higher proficiency due to class availability and curriculum constraints. The authors did mention a desire to study use of demonstrations with an experimental group consisting of the less proficient students (Erlis & Subramaniam, 2004).

Because the definition of demonstration (Taylor, 1988) is so broad, there are many different approaches that scientists have taken to study their effectiveness. The most traditional form of demonstration is a lecture demonstration. In this type of demonstration, the teacher sets up and performs the demonstration while students observe the outcome of the experiment.

The effectiveness of teacher- centered demonstrations was observed in a school in Tehran, Iran (Rade, 2009). Four chemistry classes of 12th grade girls were split into two groups. Two classes were put in a control group, and two classes were put into an experimental group. This was done randomly. Each class consisted of 37 girls. A standard Intelligence Quotient (I.Q.) estimating test was used to check the equivalence between the four classes, and the results showed no significant differences between them.

The experimental group was taught traditionally with the use of the chemistry textbook and was shown 11 lecture demonstrations that related to the topics taught. The control group was taught traditionally with the use of the chemistry textbook, but no demonstrations were shown; however, the chemistry that would have been observed in the demonstration was explained verbally to the control group. Each class was given a series of nine quizzes written on the basic concepts of the topics learned. One quiz was given after each topic was taught. A

comprehensive test was also given at the end of the semester testing all of the topics previously taught and quizzed on. The results supported the hypothesis that the group shown demonstrations achieved higher scores than the control group (Rade, 2009).

These results show the significance of chemistry lecture demonstrations in a chemistry class, but what about other classes and subjects? It has been found that the use of lecture based chemistry demonstrations can also aid psychology students as well (Venneman et al., 2009). A study was conducted on a doctoral psychology program at the University of Houston-Victoria. Many of the students in this doctoral program had undergraduate degrees in psychology and had not taken biology or chemistry courses. This was problematic in understanding many of the biochemistry content involved in the doctoral program. In order to give the students some much needed background information, demonstrations were considered.

Two hypotheses were studied. The first hypothesis was that reading the text material would increase student understanding of neuronal function over no preparation outside of class, and the second hypothesis was that observing four simple chemistry demonstrations would significantly increase student understanding of neuronal function over reading the text only.

Fifty-seven students were involved in the study with 61% being Caucasian, 29% Hispanic and 10% African American and other. Twenty-nine were assigned to the experimental group and twenty-eight to the control group. The experimental group was given a pre-test after an assigned reading on neuronal properties and function. The control group was given the same pre-test without any assigned reading. The control was therefore tested on its previous

knowledge of the material without any pre-reading assistance. Lecture demonstrations were then performed for the experimental group with the professor setting up and demonstrating the phenomena. No such opportunity was provided for the control group. The pre and post-test scores were examined for the first hypothesis that tested whether assigning reading before a lecture was useful in increasing students understanding of neuronal function. While the experimental group did score higher than the control group not assigned to read the text before class, the experimental group only averaged a 40% on the pre-test with a standard deviation of 28.80 vs. control group which averaged 19.09% on the pre-test with a standard deviation of 16.88. The gains of the experimental group were not significant enough to obtain a "passing grade" on the pre-test by scoring only 40% even though the material in question was presented in the reading. The results for the second hypothesis where lecture demonstrations were included were more significant for the experimental group. The results were highly significant with post-test scores averaging 71.43%. This study showed that demonstrations increased student comprehension over the control which saw no demonstrations (Venneman et al., 2009).

Methods of demonstrations are not limited to a teacher standing in front of a classroom and having students observe from their desks only. To keep students more actively involved in the demonstrations, researchers in Australia took traditional lecture demonstrations and modified them to have more involvement from the students at Swinburne University of Technology in Melbourne, Australia. The study consisted of large lecture classes that ranged from 200-450 students. The researchers took three of the six traditional lectures on Operational Amplifiers (OPAMPs) and replaced them with interactive lecture demonstrations.

The control group had no substitution for the six traditional lectures and the experimental group consisted of the three interactive lecture demonstrations. Pre-tests were given right after an introduction to OPAMPs were taught by traditional lecture style and then a post-test was given to both the experimental and control groups after completion of the OPAMPs unit. The pre-test and post-test consisted of seven questions and were developed to specifically test the OPAMPs concepts addressed in the unit. Although the pre-test results showed comparable understanding between the control and experimental groups, the authors do acknowledge that the questions require more fine tuning. The researchers treated the questions as independent items and found no significant statistical change in the scores from the pre-test to post-test in the control group (5%). The experimental group, however, showed a dramatic improvement of 29.1% from pre-test to post-test scores (Mazzoline, et al., 2011).

McKee et al. (2007) conducted a study to determine if demonstrations are useful in allowing students to understand the concepts as a science lab on the same topic(s). Three teaching assistants (TA) were each assigned two lab sections at a public southwestern university in the United States. One of the TA's lab sections was randomly selected to act as the control group and the other the experimental. The control group was given the laboratory assignment and asked to complete it traditionally according to the lab instructions provided. The experimental group however, observed the lab being done strictly by the TA as a demonstration. The lab performed in this study dealt with calcium reacting with hydrochloric acid to produce hydrogen gas forming a 1:2 molar ratio of the reactants used once the equation was balanced.

A pre and post-test was used in the study to determine which method increased the students' conceptual understanding. Both tests included similar questions designed to test the content learned in the lab experiment performed. The findings showed that significant learning did occur in both groups. McKee et al. (2007) showed that demonstrations were as effective if not more so than labs when trying to enhance students understanding of the concept.

Demonstrations have been not only used to help engage students, but also to increase their understanding of the topics taught in the classroom. Most of the studies on demonstrations were conducted at the collegiate level or in single gender high schools. This study looked at the success of demonstrations at the high school level within a co-ed gender population.

Materials and Methods

The purpose of this research was to investigate the usefulness of demonstrations in a co-ed high school chemistry class. The study took place in a K-12th grade private school in Baton Rouge, Louisiana, that consists of both male and female students. The high school contains 500 students. The school gives no scholarships and, therefore, contains no free or reduced lunches for its student population. Also, because the school is private, no accommodations are required for students with learning disabilities. However, students with disabilities are in my classroom. Those students are taught and tested the same way as all other students. The chemistry class used in the study consisted of 96 students split between five sections of a regular chemistry course. Each section consisted of roughly 19 students. The school- wide population (Figure 1)

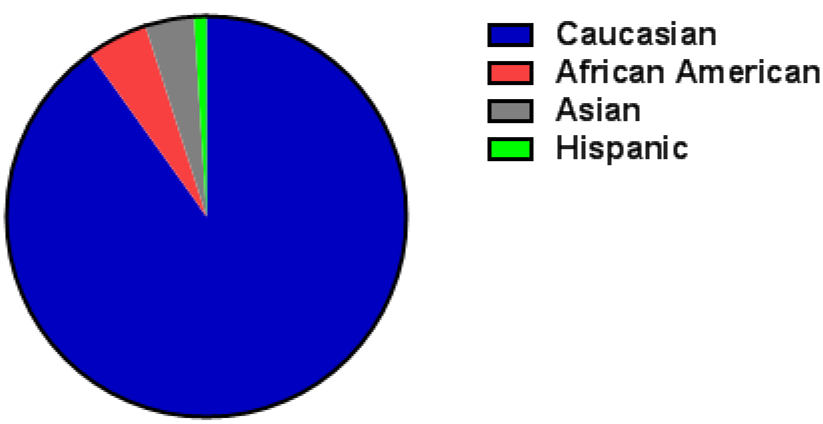


Figure 1: Parkview Baptist School Demographics.
(Each section represents the percentage of that ethnic group's attendance in high school at Parkview Baptist School. Those percentages are 91% Caucasian, 5% African American, 4% Asian, and 1% Latin.)

consists of 91% Caucasian, 5% African American, 4% Asian, and 1% Hispanic with 54% males and 46% females. The demographic of the study population in the chemistry classes (Figure 2)

is similar to that of the school-wide population containing 91% Caucasian, 7% African American, and 2% Hispanic with an average of 53% males and 47% females.

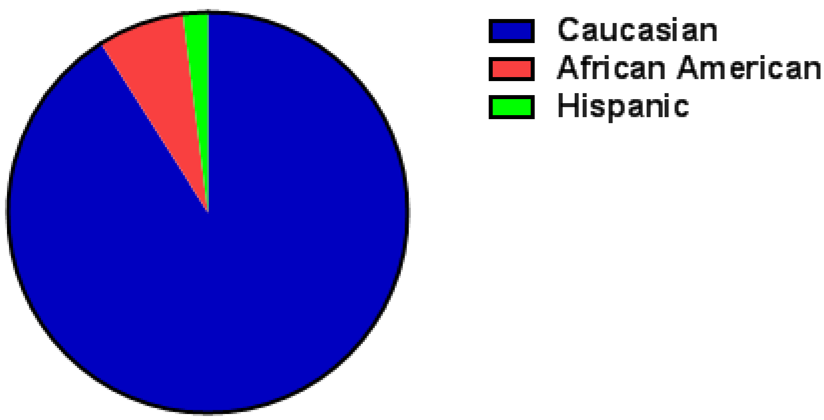


Figure 2: Parkview Baptist School College Preparatory Chemistry Class Demographics.
(Each section represents the percentage of that ethnic group's attendance in high school at Parkview Baptist School in a college prep chemistry class. Those percentages are 91% Caucasian, 7% African American, 2% Latin.)

The purpose of the study was to determine whether the use of demonstrations within a regular high school chemistry class aids students in understanding the concepts discussed and taught throughout the course of the chosen chapter. The first topic the study covered was on "Matter and Change" which is Chapter 1 from the textbook *Modern Chemistry* (Davis et al, 2009) used by the school. The five chemistry classes were split into experimental and control groups randomly. Three sections acted as the experimental group for the first part of the experiment and the remaining two sections were the control group. Sections 1, 2 and 6 were the randomly selected experimental sections and sections 4 and 5 the control sections. All five sections were given a pre-test to determine what, if any, prior knowledge the students had on the topics taught. The students were informed that the pre-test would not count for a grade

and would not affect their overall grade in the class. The pre-test (Appendix A) consisted of 15 multiple choice questions with four answer choices for each question. These questions came from the Exam View software provided by the text book company along with questions from previous New York State Regents exams. Exam View (2009) is supplemental software provided by the publisher of the *Modern Chemistry* textbook. These questions are correlated with state standards and are considered high value and grade suitable. The questions were chosen to specifically test the material in which demonstrations were used as part of the lesson. The students were given sufficient opportunity to finish the pre-test and they were turned in to the teacher. The answers to the pre-test, were immediately discussed with the students, but the pre-test was not given back.

Once the pre-test was administered, the instructor began teaching the material in Chapter 1. The experimental group was taught with traditional lecture style and discussion and had demonstrations performed (Table 1) by the teacher throughout the chapter when appropriate. While the demonstrations were performed, the teacher explained what the students were observing and asked probing questions of the students to assess their understanding of the demonstration in reference to the material taught. Once the material on Chapter 1 was covered completely, the students in the experimental group were given a post-test (Appendix A). The post-test consisted of the same 15 questions used on the pre-test with the order of the questions rearranged. Chapter 1 took ten classroom days to cover in the experimental group.

Table 1: Chapter 1 Demonstrations, Descriptions and References. *

Demonstration	Description	Reference-Source
Extensive and Intensive Physical Properties	Mass and volume (using water displacement) of metal shot was determined and then density was calculated. The amount of metal shot was then varied showing mass and volume to be extensive properties and density was calculated each time showing the density to be the same (intensive property)	*Hands-On Chemistry Activities with Real-Life Applications* Pages 186-187
Physical and Chemical Changes	Iron fillings and powdered sulfur were mixed. A magnet was used to separate the two. This showed they each kept their own physical properties. The mixture was then heated until a complete reaction took place between the sulfur and iron. The magnet was again used but this time the whole new substance was magnetized showing a chemical change had occurred.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 178-179
Basic Properties of Gases	In order to show that gases, like liquids and solids have mass, a flat kick-ball was massed then filled with air and massed again and the difference found. To show that gases take up space, paper was balled up and stuck in the bottom of a beaker. The beaker was then inverted into a larger beaker full of water. Once removed the paper was shown to the class to be dry. To show that gases expand, air freshener was sprayed in one corner of the room and students raised their hands when they could smell the scent.	*Hands-On Chemistry* Activities with Real-Life *Applications* Pages 436-438
Separation of Pure Substances and Mixtures	Basic chromatography was done using water soluble markers to show the mixture of colors used the original marker color. The students were able to identify mixtures if more than one color existed and a pure substance if only once color existed.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 180-182

***** Includes the topics on which the demonstrations were performed in Chapter 1 with descriptions of the demonstrations and a reference from where the demonstration can be found.

The control group also began Chapter 1 as soon as the pre-test (Appendix A) was complete. The control group was taught with the same traditional lecture style and discussion as the experimental group. No demonstrations were performed on the material taught in this chapter. However, the teacher described what the demonstrations looked like to the students

and also asked probing questions of the students (Rade, 2009). This allowed the teacher to use roughly the same amount of class time the experimental group required observing the demonstrations. This permitted the teacher to finish both the control and experimental groups' chapter at the same time. Once the Chapter 1 material was complete, the control group took the same post-test (Appendix A) as the experimental group. The material for the control group took ten classroom days as well.

The next chapter included in the study was material covered in Chapter 6 "Chemical Bonding" of the *Modern Chemistry* textbook (Table 2). The two sections that made up the control group during Chapter 1 became the experimental group in Chapter 6. This left the three sections that were originally the experimental group to act as the control group. A pre-test (Appendix B) was again administered to all five sections and consisted of 15 multiple choice questions with four answer choices for each question. Again, once the students completed their quizzes, the instructor collected them and then went over all of the quiz questions and answers.

The teacher then repeated the same process for the experimental group and control group for Chapter 6 that were done for the Chapter 1 experimental and the control groups. Both groups were given a post-test (Appendix B) once all of the chapter material was covered. The post-test for Chapter 6 also consisted of identical questions to those found on the pre-test with the questions rearranged.

The third chapter used included material covered in Chapter 10 "States of Matter" of the *Modern Chemistry* textbook (Table 3). The control and experimental groups in this chapter mirrored the groups used in Chapter 1. Chapter 11 "Gases" acted as the final chapter in the study (Table 4). The groups used as the control in Chapter 10 became the experimental and the

experimental in Chapter 10 became the control in Chapter 11. The teacher again repeated the same process for both Chapters 10 and 11 that were used in the previous chapters of study

Table 2: Chapter 6 Demonstrations, Descriptions and References. *

Demonstration	Description	Reference
Covalent and Ionic Bonding	Solutions of table salt, table sugar, rubbing alcohol, vinegar and bleach were all made. A multi-meter was placed into each one to show whether or not it produced a current. Ionic solutions produced a current and covalent did not.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 206-207
Nonpolar and Polar Covalent Bonds	Burets were filled with water, rubbing alcohol and cyclohexane respectively. The stopcock of each burette was released separately while a comb that had been rubbed with wool was brought close to the stream. The more polar the liquid the more it was attracted to the comb which was positively charged by the wool.	*Hands-On Chemistry Activities with Real-Life Applications* Page 205
Metallic Bonding	A multi-meter was used to determine electrical resistance between copper, copper sulfate, aluminum, aluminum sulfate, iron and iron sulfate. The multi-meter showed that only the solid metals allowed electricity to flow through them.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 208-209
Intermolecular Forces	To show surface tension of liquids a vortex was formed. To show that different liquids have different strengths of intermolecular forces, a drop of water and rubbing alcohol were placed separately on a piece of wax paper and a side view of each droop was observed. To show how surface tension can allow impenetrability of liquids, a paper clip was placed on top of a beaker of water.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 210-212

*Includes the topics on which the demonstrations were performed in Chapter 6 with descriptions of the demonstrations and a reference from where the demonstration can be found.

including the administration of pre and post-test (Appendices C and D, respectively). Each test consisted of 15 multiple choice questions. Both tests consisted of the same questions rearranged in a different order.

Table 3: Chapter 10 Demonstrations, Descriptions and References.*

Demonstration	Description	Reference
Diffusion of Gases	A meter stick along with a liquid with a strong odor was placed on the demonstration table of the classroom and a time was taken to determine how long it took for each student to smell the odor. The rate of diffusion was then determined	*Hands-On Chemistry Activities with Real-Life Applications* Page 132
Density of Gases and Liquids	Gases: Popcorn kernels were massed then popped. A determination of the amount of water loss was found. Liquids: A dynamic density gradient was created with different liquids that have varying densities.	*Hands-On Chemistry Activities with Real-Life Applications* Page 437 and 71
Phase Diagrams	Dry ice was pressurized using a plastic dropper, pliers and a beaker of water in order to observe a forced phase change into a liquid.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 162-163
Surface Tension	Water and a dropper were used to show the attraction of molecules on the surface of a liquid. A drop of water was placed on the demonstration table and its rounded shape was examined.	*Hands-On Chemistry Activities with Real-Life Applications* Page 211

* Includes the topics on which the demonstrations were performed in Chapter 10 with descriptions of the demonstrations and a reference from where the demonstration can be found.

It is also important to note that no labs based on the chapters studied were performed in the control or experimental groups. This was specifically done so that there would be no question on whether lab activities had any effect on the resulting calculations comparing the pre-test and the post-test and experimental treatments.

Once all chapters were completed, a normalized student learning gain was calculated using the formula: <g> = $\frac{Student's\ individual\ gain}{Student's\ maximum\ possible\ gain}$. This formula allows the instructor to

Table 4: Chapter 11 Demonstrations, Descriptions and References. *

Demonstration	Description	Reference
Boyle's Law	An eyedropper was placed into a 2-liter bottle and a Cartesian diver was created. The amount of pressure placed on the bottle determined the location of the eye dropper.	*Hands-On Chemistry Activities with Real-Life Applications* Page 439
Charles's Law	Using tissue paper and construction paper, a hot air balloon was created. Then a blow dryer was used to heat the air particles in the balloon causing the hot air balloon to rise	*Hands-On Chemistry Activities with Real-Life Applications* Page 446
Gay-Lusaac's Law	Five marbles were placed in a plastic milk jug to represent air particles. The jug is shaken at different speeds to represent different kinetic energies due to an increase or decrease in temperature.	*Hands-On Chemistry Activities with Real-Life Applications* Page 448
Avogadro's Principle	44 grams of dry ice (molar mass of CO2) were crushed and placed into a garbage bag and allowed to sublime. Once at room temperature the bag is rolled until turgid and marked. Then water is placed in the bag a liter at a time until the water reaches the mark made by the gas. The volume of gas and water should approximately match.	*Hands-On Chemistry Activities with Real-Life Applications* Pages 450-451

***Includes the topics on which the demonstrations were performed in Chapter 11 with descriptions of the demonstrations and a reference from where the demonstration can be found.

take the actual gain of the student and divide it by the potential gain to determine how much the student learned (Slater et. al, 2010 page 35). This was done for each student in the control and a mean was found using the formula: $< g > = \frac{Sum\ of\ all\ students'normalized\ gains}{Number\ of\ students}$. This formula calculated the average of the normalized gain for the control group (Slater et. al, 2010 page 35). This process was then repeated for the experimental group. The average normalized gain for the control and experimental groups were then compared using a Mann-Whitney test. A

Kruskal-Wallis (nonparametric ANOVA) with Dunn's post-test analysis was performed using GraphPad InStat version 3.10 for Windows 95, GraphPad Software, San Diego California USA, www.graphpad.com.   A parametric ANOVA was not run because the data in each chapter of study violated the assumption of normality as tested by the Kolmolgorov-Smirnoff test.

Student and parent/guardian consent forms were signed for all students involved in the study giving permission to use the results in the study. Students were assigned indicator numbers to ensure anonymity. The IRB# for this study was E6001 (Appendix E).

Analysis of Data

This study was performed to examine the effectiveness of demonstrations in a high school chemistry class to determine if students' abilities to understand the topics presented were increased. Many studies previously presented on this topic were performed at the collegiate level, at single gender high schools and/or schools in other countries. My study took take place in a private K-12 high school in Baton Rouge, Louisiana, consisting of a co-ed student body. Demonstrations are an easy, relatively inexpensive pedagogical technique educators can use to enhance their teaching. It is also something that teachers can consider incorporating into their classrooms when student labs are not possible in a given chapter or unit of study.

In all, four chapters were included in this study. Chapter 1 used demonstrations to help explain the difference between extensive and intensive properties, physical and chemical changes, the basic properties of gases and separation of pure substances compared with mixtures. In Chapter 6, the difference between covalent and ionic bonding was demonstrated along with demonstrations on nonpolar bonds compared to polar covalent bonds, metallic bonding and intermolecular forces. The diffusion of gases, comparing densities of gases and liquids, phase diagrams and surface tension were demonstrated in Chapter 10. In the final chapter of my study, Chapter 11, demonstrations on Boyle's Law, Charles's Law, Gay-Lusaac's Law, and Avogadro's principle were performed.

To determine the value of using demonstrations in a chemistry classroom, five sections of college preparatory chemistry classes at a private school were randomly separated into two groups. One group acted as the control, and the other group acted as the experimental. The two groups then switched roles in the next chapter included in the study. The control group in

the first chapter became the experimental group in the next chapter, and the experimental group in the first chapter became the control group. Because four chapters were used in this study, each group acted as the control in two chapters and the experimental in the other two chapters. Both groups were given a pre-test to start the chapter containing 15 multiple choice questions. The experimental group received a normal lecture with demonstrations incorporated where appropriate within the chapter. The control group received a normal lecture only. At the end of the chapter, both groups were given a post-test that contained the same 15 questions originally asked in the pre-test but with the questions rearranged (Appendices A, B, C and D). After completing Chapters 1, 6, 10 and 11, the data from the pre-tests and post-tests were analyzed using GraphPad InStat version 3.00 for Windows 95, GraphPad Software, San Diego California USA, www.graphpad.com. Scores were excluded from the study for any student who was not present for both the pre-test and the post-test for each chapter. A normalized learning gain and a Kruskal-Wallis (non-parametric ANOVA) were run for control and experimental groups with a Dunn's post-test analysis. Standard error of mean was also calculated and provided.

Figure 3 shows the comparison between the raw score means of the control versus the experimental groups. When comparing the pre-tests scores of both the control and experimental groups in Chapter 1, no significant difference was found between the two groups ($P>0.05$) indicating both groups had similar prior knowledge of the material taught in the chapter. The results of the post-test also show no significant difference ($P>0.05$) between the post-test scores of both groups.

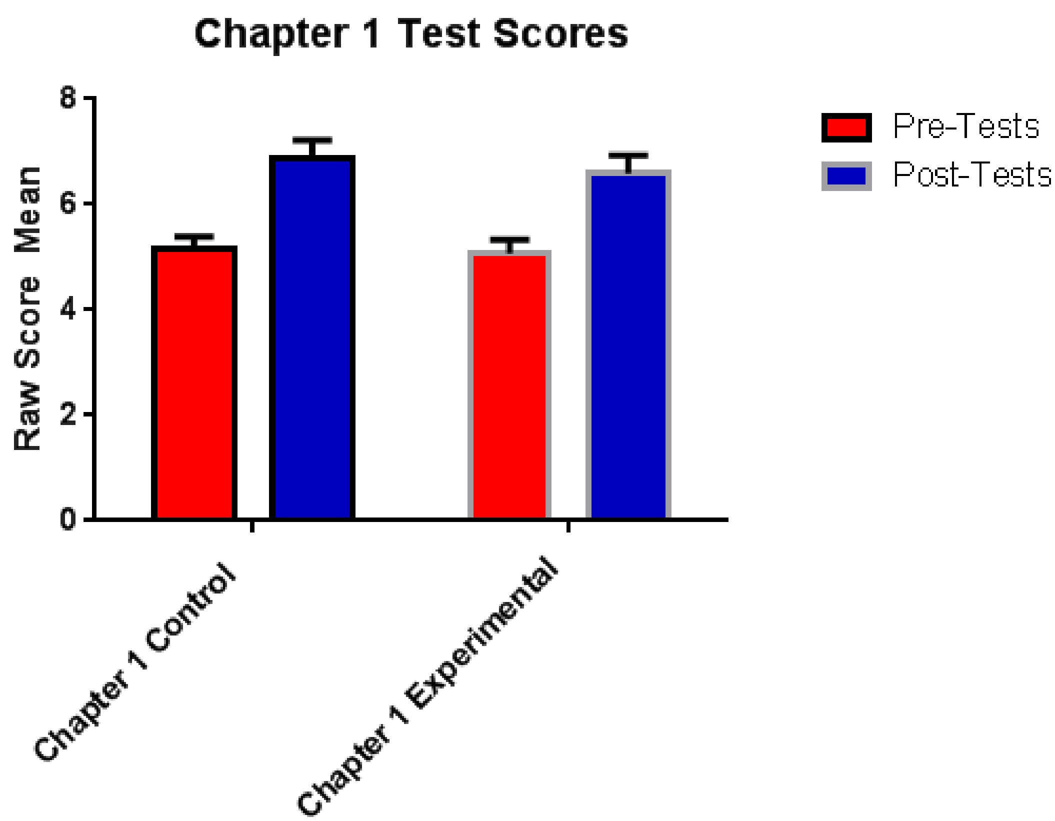


Figure 3: Chapter 1 Control versus Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 1 which covered extensive and intensive physical properties, physical and chemical changes, basic properties of gases, and separation of pure substances compared to mixtures. Results including standard error of mean bars show the control group scored slightly higher on the post-test than the experimental group.)

The normalized learning gains (see Figure 4) shows that no statistical difference was found between the control and experimental groups ($P>0.05$, NLG Control= 0.168 ± 0.0342; NLG Experimental=0.141 ± 0.0334). These results show no indication that using demonstrations helped students learn and understand the topics studied in Chapter 1. In fact, just the opposite is suggested with the control finishing with a slightly higher raw mean score and normalized learning gain.

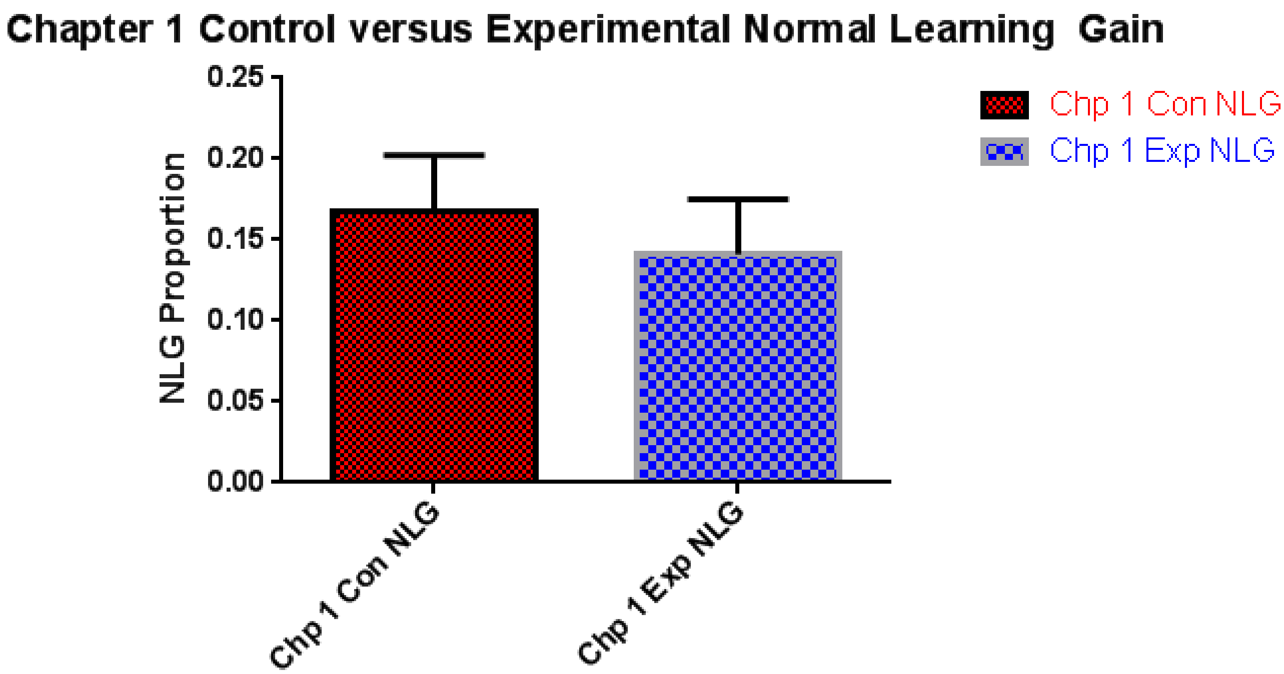


Figure 4: Chapter 1 Normalized Learning Gain.
(The y-axis represents the proportion of knowledge gained. The bar labeled Chp 1 Con NLG represents the proportion of knowledge gained by the control from pre-test to post-test. The bar labeled Chp 1 Exp NLG represents the proportion of knowledge gained from pre-test to post-test by the experimental. Results including standard error of mean bars show that the control group had a higher learning gain from pre-test to post-test in Chapter 1 compared with the experimental group. NLG=Normalized Learning Gain).

No significant difference in the pre-test scores of the control or the experimental groups ($P>0.05$) were found indicating similar prior knowledge. Though the post-tests of the control and experimental group contained no significance ($P>0.05$), when examining Figure 5 it can be observed that the experimental group was slightly below the control group's raw mean score on the pre-test. After the use of demonstrations, the experimental group "caught up" to the control group's raw mean post-test score showing a higher normalized learning gain, seen in Figure 6, (NLG Control = 0.146 ± 0.0353; NLG Experimental = 0.224 ± 0.031). Based on these

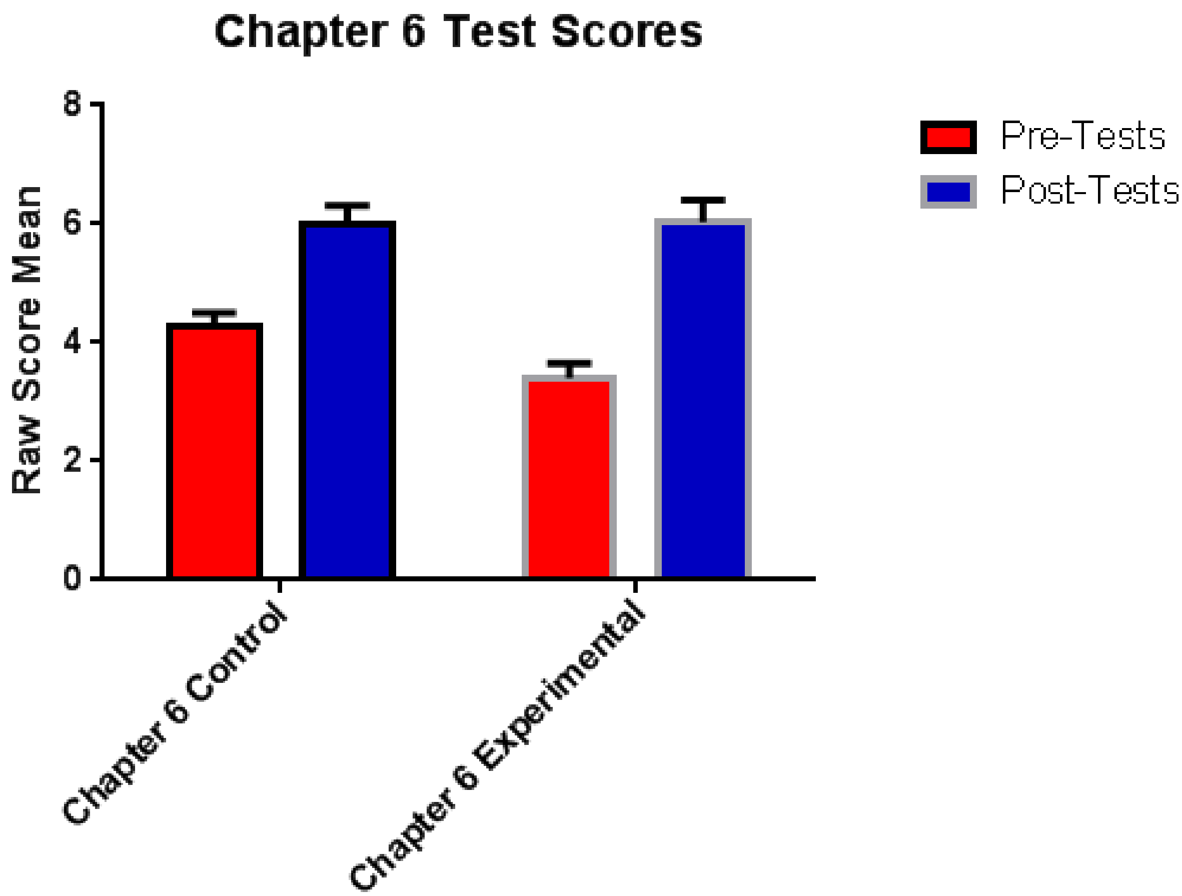


Figure 5: Chapter 6 Control versus Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 6 which covered covalent and ionic bonding, nonpolar and polar covalent bonds, metallic bonding, and intermolecular forces. Results including standard error of mean bars show the experimental group scored slightly higher on the post-test than the control group.)

results, the experimental group did show a trend of gaining more knowledge. It is important to note however that there was no significance found between the normalized learning gain of the control and experimental groups (P>0.05)

The Chapter 10 raw mean scores between the pre-test and post-test and normalized learning gains comparing control and experimental groups can be seen in Figures 7 and 8,

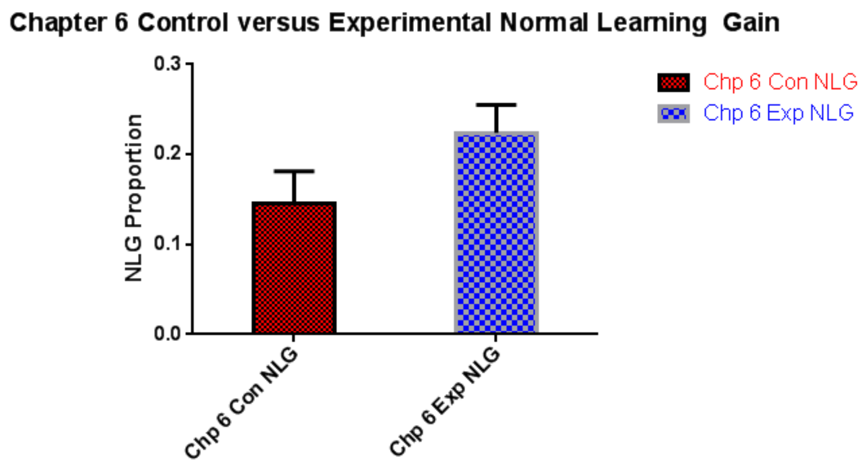


Figure 6: Chapter 6 Normalized Learning Gain.
(The y-axis represents the proportion of knowledge gained. The bar labeled Chp 6 Con NLG represents the proportion of knowledge gained by the control from pre-test to post-test. The bar labeled Chp 6 Exp NLG represents the proportion of knowledge gained from pre-test to post-test by the experimental. Results including standard error of mean bars show no statistical significance between experimental group from pre-test to post-test in Chapter 6 compared with the control group. NLG= Normalized Learning Gain)

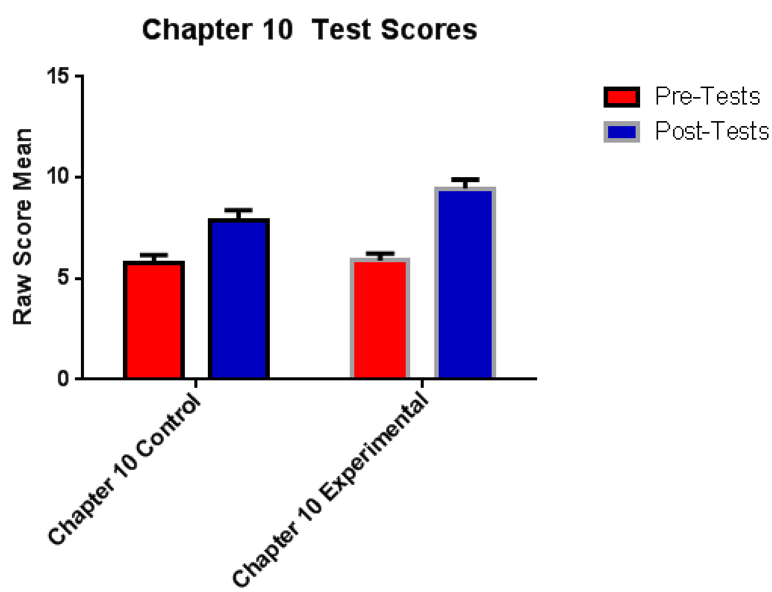


Figure 7: Chapter 10 Control versus Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 10 which covered diffusion of gases, density of gases and liquids, phase diagrams, and surface tension. Results including standard error of mean bars show the experimental group scored slightly higher on the post-test than the control group.)

respectively. The pre-test scores again showed no differences (P>0.05) indicating both the control and experimental groups started with similar familiarity. While again no differences (P>0.05) were found between the control and experimental groups raw mean scores on the post-test, a trend was once more detected with slightly higher post-test scores from the experimental group. There was a very significant difference (P=0.0084) in the normalized learning gains (NLG Control= 0.245 ± 0.0419; NLG Experimental= 0.407 ± 0.0331) between the control and experimental groups. These data indicates the experimental group did gain substantially more knowledge than the control group in Chapter 10.

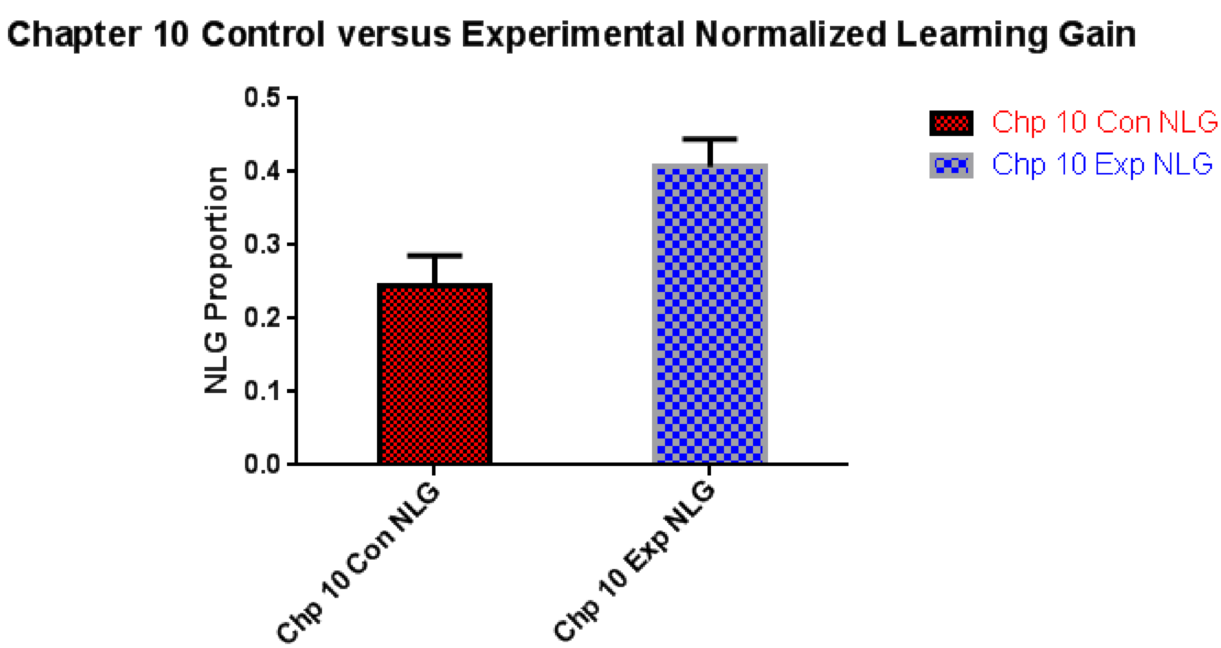


Figure 8: Chapter 10 Normalized Learning Gain.
(The y-axis represents the proportion of knowledge gained. The bar labeled Chp 10 Con NLG represents the proportion of knowledge gained by the control from pre-test to post-test. The bar labeled Chp 10 Exp NLG represents the proportion of knowledge gained from pre-test to post-test by the experimental. Results including standard error of mean bars show that the experimental group had a higher learning gain from pre-test to post-test in Chapter 10 compared with the control group. NLG= Normalized Learning Gain)

In Chapter 11, the experimental and control groups again came in with similar knowledge showing no differences between the pre-test scores of these two groups (P>0.05). Similar to the previous chapters, no significant differences were found between the control and experimental groups' post-test scores (P>0.05).The trend suggested in Chapters 6 and 10 are again seen here in Chapter 11 when comparing the raw mean scores of the control and experimental groups. The raw scores are higher in the experimental group for Chapter 11 which can be observed in Figure 9.

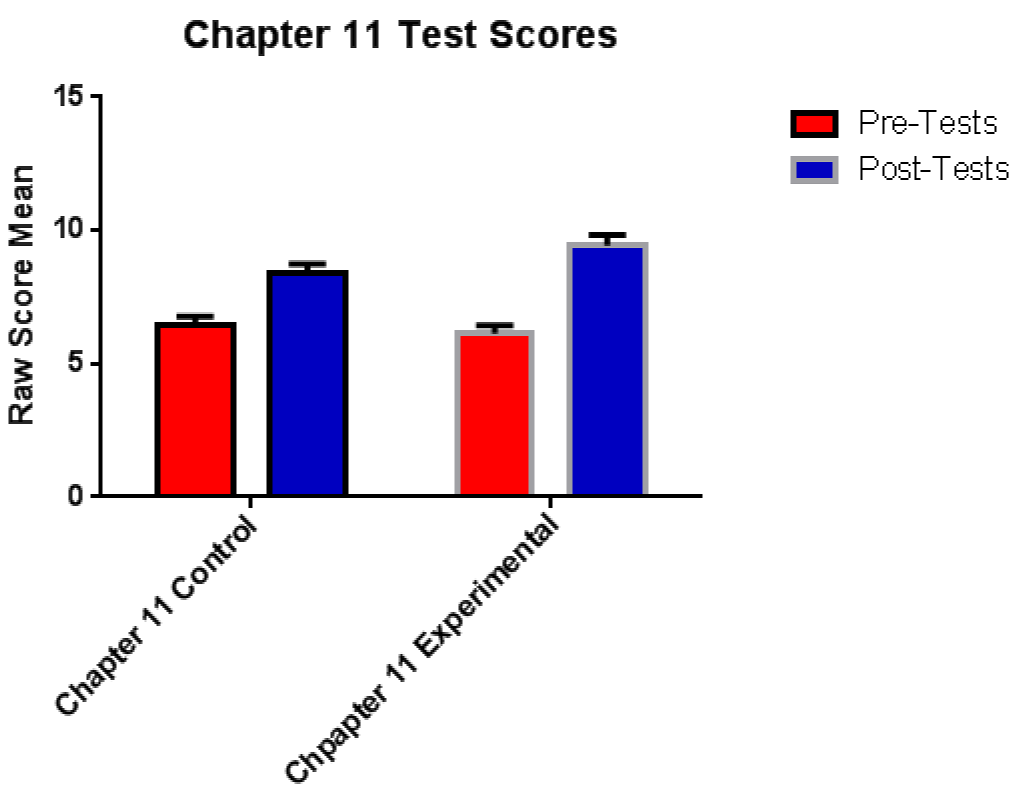


Figure 9: Chapter 11 Control versus Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 11 which covered Boyle's Law, Charles's Law, Gay-Lusaac's Law and Avogadro's Principle. Results including standard error of mean bars show the experimental group scored slightly higher on the post-test than the control group.)

Like Chapter 10, Chapter 11 did show an extremely significant statistical difference (P = 0.0002) between the control group's normalized learning gain and the experimental group's normalized learning gain (NLG Control=0.226 ± 0.0338; NLG Experimental = 0.390 ± 0.0338) which can be witnessed in Figure 10.

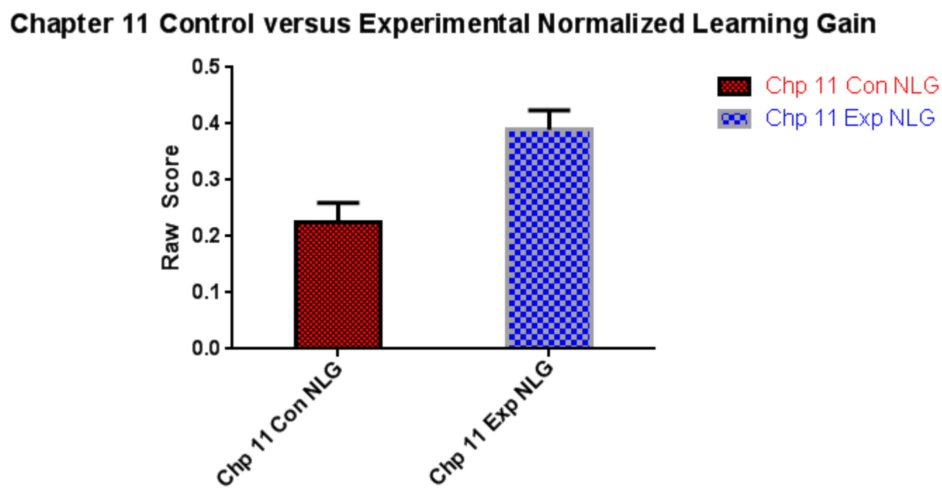


Figure 10: Chapter 11 Normalized Learning Gain.
(The y-axis represents the proportion of knowledge gained. The bar labeled Chp 11 Con NLG represents the proportion of knowledge gained by the control from pre-test to post-test. The bar labeled Chp 11 Exp NLG represents the proportion of knowledge gained from pre-test to post-test by the experimental. Results including standard error of mean bars show that the experimental group had a higher learning gain from pre-test to post-test in Chapter 11 compared with the control group. NLG= Normalized Learning Gain)

An examination of how males and females did in each chapter was also completed. In Chapter 1 no significance (P>0.05) was found between the raw scores of the males and the females in the control or experimental group from pre-test to post-test. In the control group, the females started slightly higher than the males on the pre-test scores and finished slightly higher than the males on the post-test (Figure 11). When examining the experimental group's scores broken down by male and females, the trend lines are almost directly on top of one another again suggesting no difference between the two groups (Figure 12).

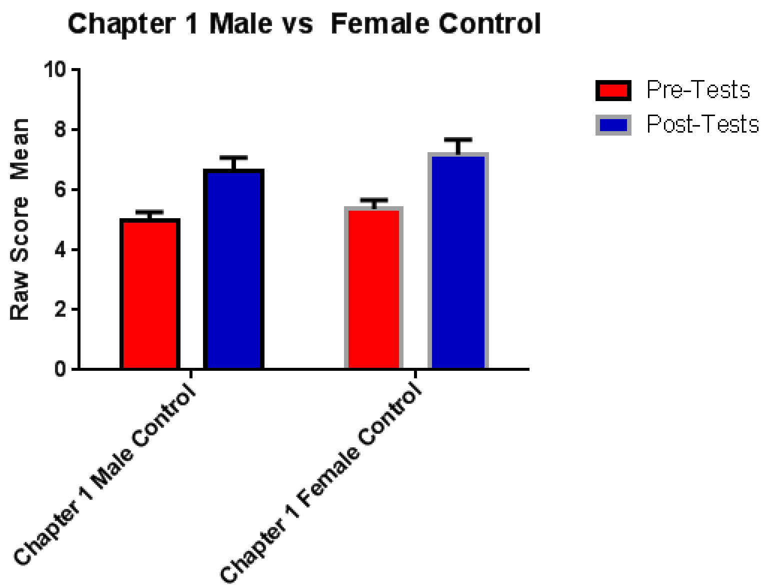


Figure 11: Chapter 1 Male Control vs. Female Control.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 1 which covered extensive and intensive physical properties, physical and chemical changes, basic properties of gases, and separation of pure substances compared to mixtures. Results including standard error of mean bars show the females in the control group scored slightly higher on the pre and post-test compared with the males in the control group.)

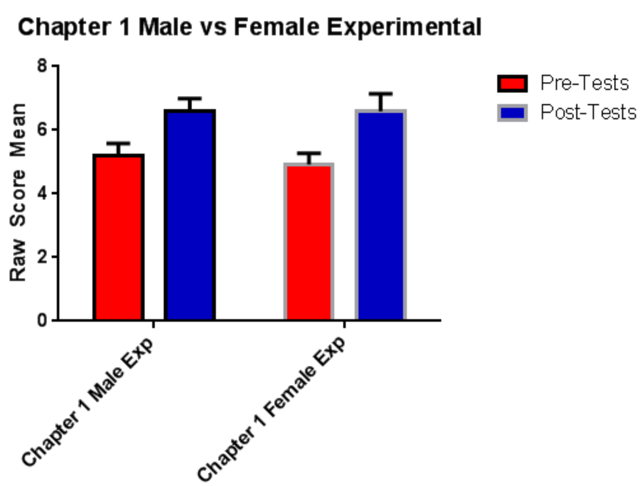


Figure 12: Chapter 1 Male Experimental vs. Female Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 1 which covered extensive and intensive physical properties, physical and chemical changes, basic properties of gases, and separation of pure substances compared to mixtures. Results including standard error of mean bars show the male experimental group scored slightly higher on the pre-test than the female experimental group, but post-test scores are almost identical.)

A normalized learning gain was also calculated comparing the Chapter 1 control group males with the Chapter 1 control group females, the Chapter 1 experimental group males and females. As expected from the raw scores seen in the previous figures, no differences were found in the normalized learning gain (P>0.05).

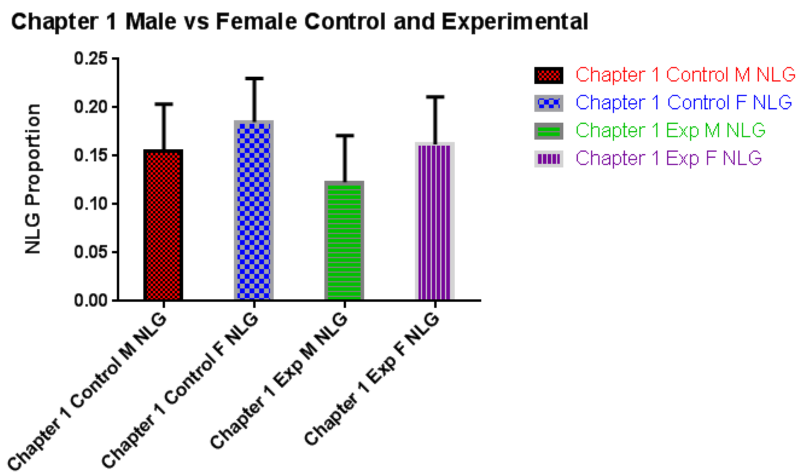


Figure 13: Chapter 1 Male vs. Female Control and Experimental Normalized Learning Gain. (The y-axis represents the proportion of knowledge gained. The bar labeled Chapter 1 Control M NLG represents the proportion of knowledge gained by the male control group from pre-test to post-test. The bar labeled Chapter 1 Control F NLG represents the proportion of knowledge gained from pre-test to post-test by the female control group. The bar labeled chapter 1 Exp M NLG represents the proportion of knowledge gained by the male experimental group, and the bar labeled Chapter 1 Exp F NLG represents the proportion of knowledge gained by the female experimental group. Results including standard error of mean bars show that both the control groups had a higher learning gain from pre-test to post-test in Chapter 1 compared with the experimental group. Also females did better in both the control group and experimental group. NLG= Normalized Learning Gain)

When breaking down Chapter 6 into male and female groups, no significance (P>0.05) was found in the raw scores in the control (Figure 14). The males began with slightly less prior knowledge than the females but finished with slightly more when looking at the post-test scores. In comparison, the females in the experimental group started out with slightly more prior knowledge than the males and finished slightly above (Figure 15).

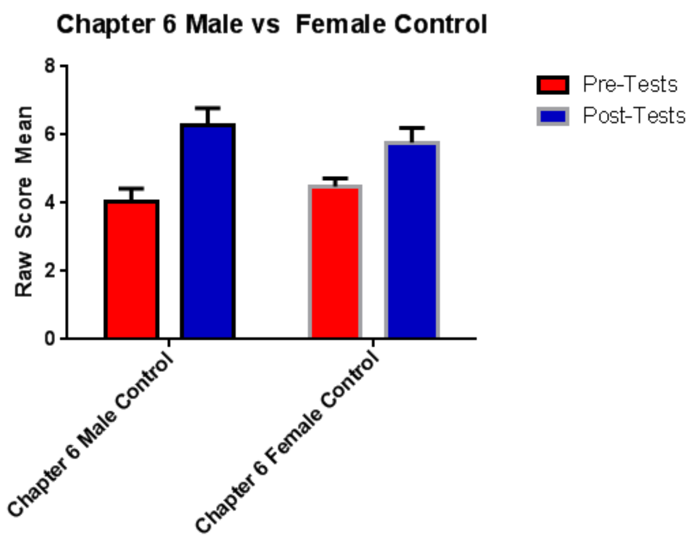


Figure 14: Chapter 6 Male Control vs. Female Control.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 6 which covered covalent and ionic bonding, nonpolar and polar covalent bonds, metallic bonding, and intermolecular forces. Results including standard error of mean bars show the control group females slightly higher on the pre-test than the control group males but the control group males finished slightly higher than the control group females.)

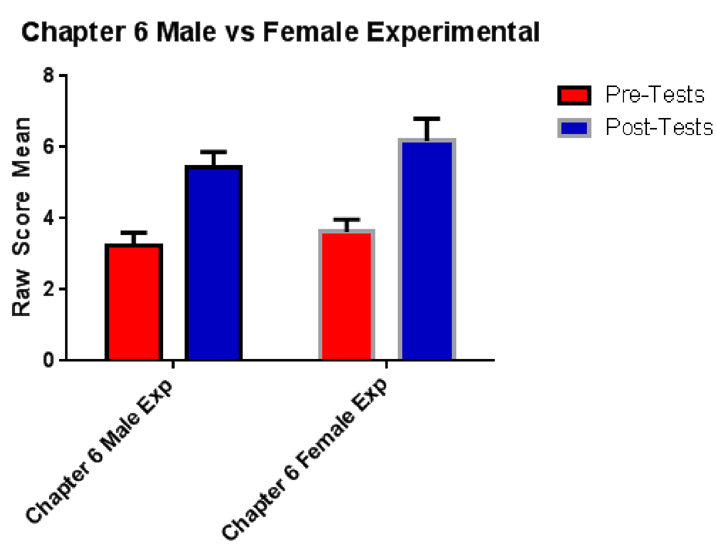


Figure 15: Chapter 6 Male Experimental vs. Female Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 6 which covered covalent and ionic bonding, nonpolar and polar covalent bonds, metallic bonding, and intermolecular forces. Results including standard error of mean bars indicate the female experimental group scored slightly higher on the pre and post-tests compared to the males in the experimental group.)

When examining the normalized learning gains observed in Chapter 6 (Figure 16), it again contained no difference (P>0.05). However, the learning gains in this chapter are opposite from those in Chapter 1. In Chapter 6 the males had higher learning gains in both the control and the experimental groups.

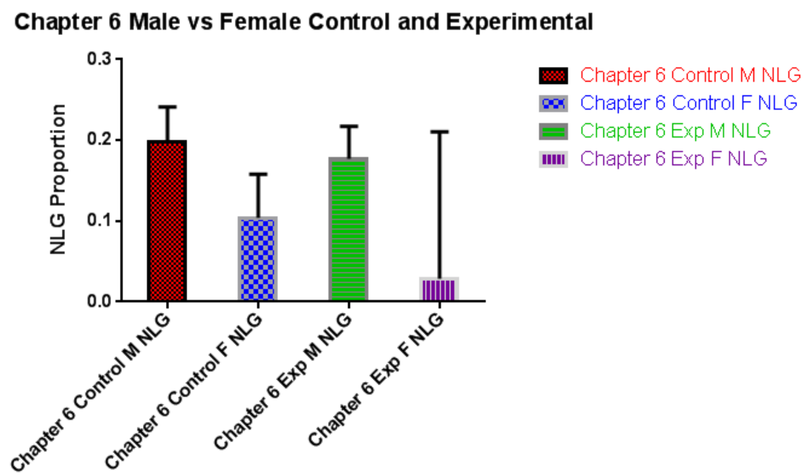


Figure 16: Chapter 6 Male vs. Female Control and Experimental Normalized Learning Gain. (The y-axis represents the proportion of knowledge gained. The bar labeled Chapter 6 Control M NLG represents the proportion of knowledge gained by the male control group from pre-test to post-test. The bar labeled Chapter 6 Control F NLG represents the proportion of knowledge gained from pre-test to post-test by the female control group. The bar labeled Chapter 6 Exp M NLG represents the proportion of knowledge gained by the male experimental group, and the bar labeled Chapter 6 Exp F NLG represents the proportion of knowledge gained by the female experimental group. Results including standard error of mean bars show that both the control groups had a higher learning gain from pre-test to post-test in Chapter 6 compared with their experimental group based on gender. NLG= Normalized Learning Gain)

In Chapter 10 both the control and experimental group males and females started with almost identical raw pre-test scores which can be observed in Figure 17. In the control group, though, the females finish slightly higher than the males though no significance was found (P>0.05). In the experimental group, again no statistical significance was observed (P>0.05), but the males finished slightly higher than the females (Figures 18) on the post-test. The males began with insignificantly higher score on the pre-test.

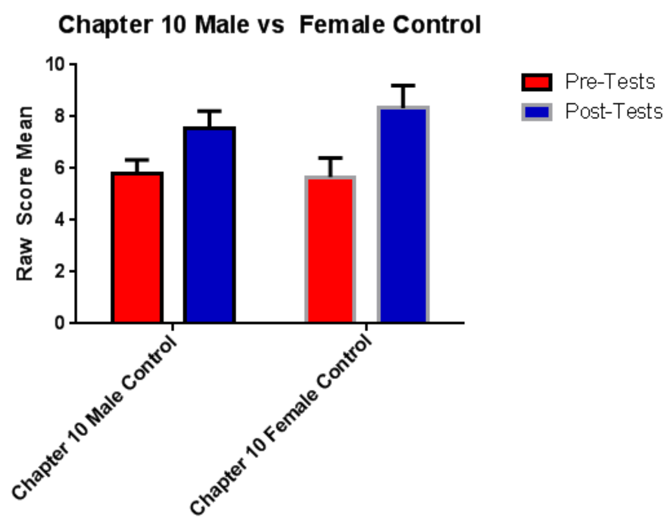


Figure 17: Chapter 10 Male Control vs. Female Control.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 10 which covered diffusion of gases, density of gases and liquids, phase diagrams, and surface tension. Results including standard error of mean bars show the control males and females scores on the pre-test were almost identical. The females post-test scores were higher, however, than the males in the control group for Chapter 10.)

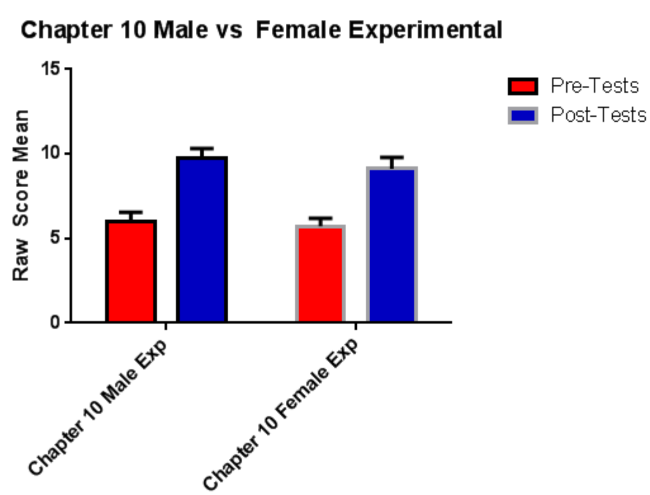


Figure 18: Chapter 10 Male Experimental vs. Female Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 10 which covered diffusion of gases, density of gases and liquids, phase diagrams, and surface tension. Results including standard error of mean bars show the males were only slightly higher scoring on the pre-test in the experimental group and finished a little higher than the females on the post-test.

When examining the normalized learning gains in Chapter 10, no differences were found between the males and females (P>0.05) in the experimental group or control group (Figure 19). This again does not indicate any particular trend of the effects of demonstrations based on gender.

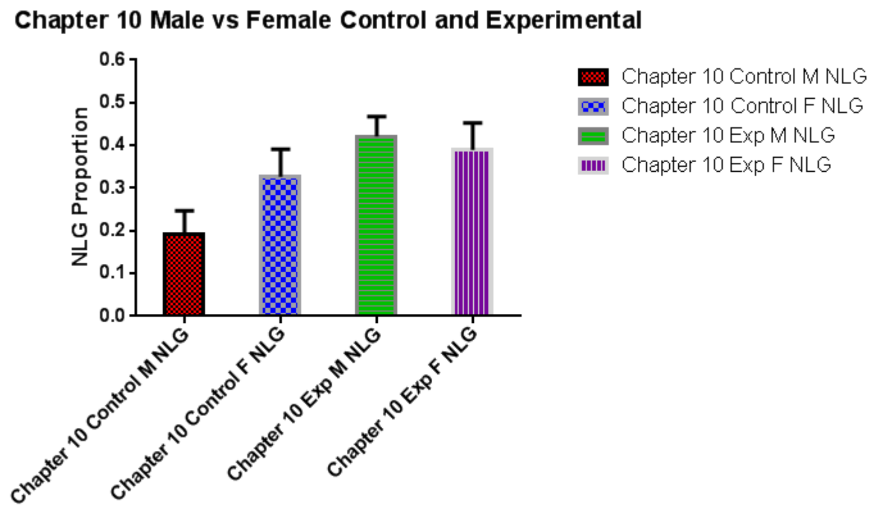


Figure 19: Chapter 10 Male vs. Female Control and Experimental Normalized Learning Gain. (The y-axis represents the proportion of knowledge gained. The bar labeled Chapter 10 Control M NLG represents the proportion of knowledge gained by the male control group from pre-test to post-test. The bar labeled Chapter 10 Control F NLG represents the proportion of knowledge gained from pre-test to post-test by the female control group. The bar labeled chapter 10 Exp M NLG represents the proportion of knowledge gained by the male experimental group, and the bar labeled Chapter 10 Exp F NLG represents the proportion of knowledge gained by the female experimental group. Results including standard error of mean bars show that both the experimental groups had a higher learning gain from pre-test to post-test in Chapter 10 compared with the control group. Females did better in the control group, and males learned slightly more in the experimental group. NLG= Normalized Learning Gain)

Chapter 11, the final chapter included in this study, Figures 20 and 21 represent the raw score comparisons of the males and females in the control group and the males and females in the experimental group. The males started slightly higher on the pre-test scores and finished slightly higher on the post-test scores than did the females in the control groups (Figure 20). This difference however was not found to be significant (P>0.05).

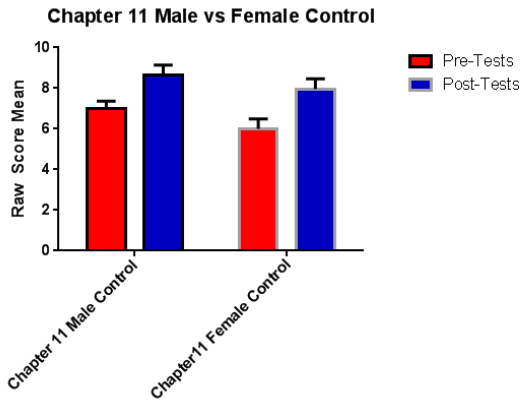


Figure 20: Chapter 11 Male Control vs. Female Control.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 11 which covered Boyle's Law, Charles's Law, Gay-Lusaac's Law and Avogadro's Principle. Results including standard error of mean bars show the male control group scored slightly higher on the pre and post-tests when compared with the female control group in Chapter 11.)

In the experimental groups the females finished marginally above the males in their post-test raw scores (Figure 21), but again not significantly (P>0.05).

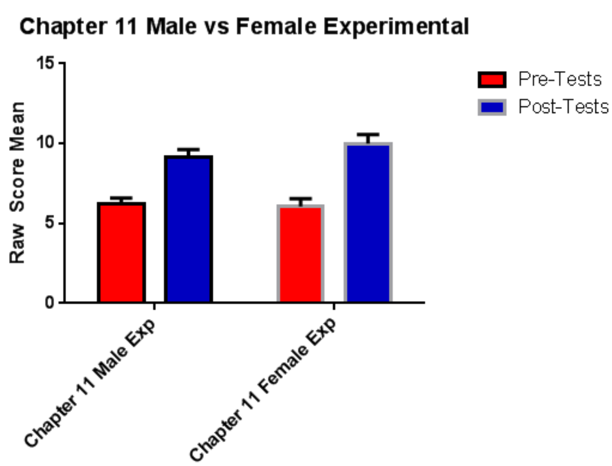


Figure 21: Chapter 11 Male Experimental vs. Female Experimental.
(Each bar represents the average correct score (out of 15 questions). The material tested was on Chapter 11 which covered Boyle's Law, Charles's Law, Gay-Lusaac's Law and Avogadro's Principle. Results including standard error of mean bars show the male and female experimental groups scored similar pre-test scores with the females marginally out-scoring the males on the post-test than the control group.)

Chapter11's normalized learning gains between the groups was also found to not be significant (P>0.05). In this instance, both males and females gain a very similar amount of knowledge in the control group. The females learned more than the males in the experimental group, but again none of these differences were found to be significant (Figure 22).

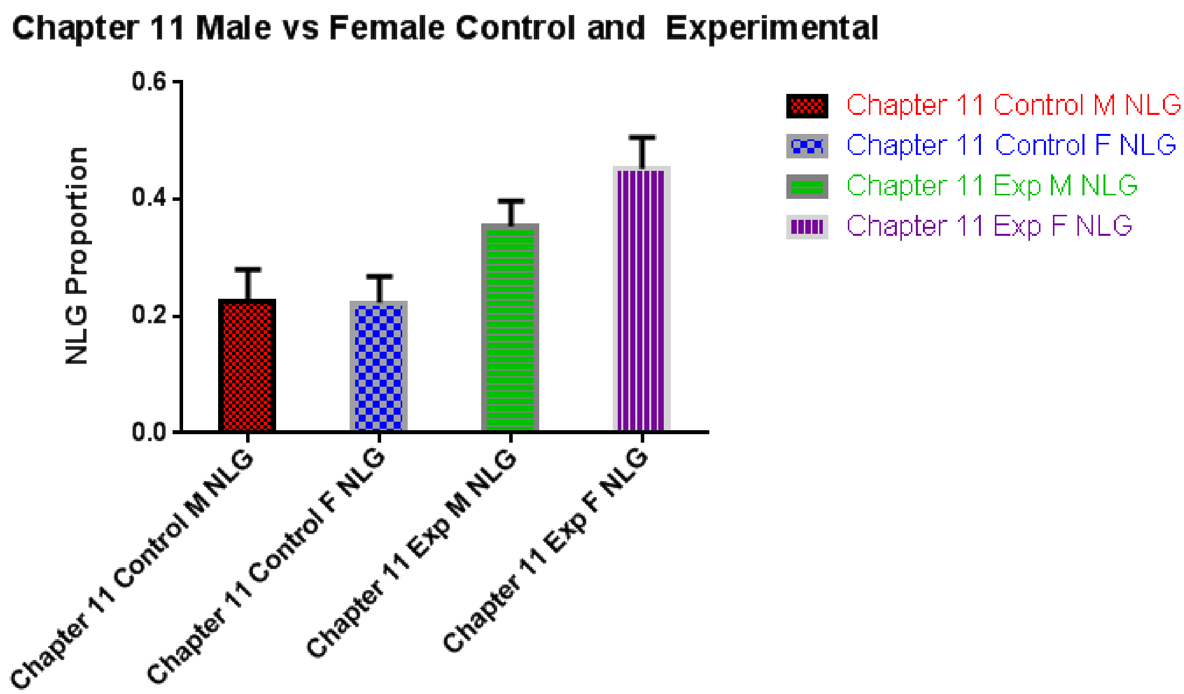


Figure 22: Chapter 11 Male vs. Female Control and Experimental Normalized Learning Gain. (The y-axis represents the proportion of knowledge gained. The bar labeled Chapter 11 Control M NLG represents the proportion of knowledge gained by the male control group from pre-test to post-test. The bar labeled Chapter 11 Control F NLG represents the proportion of knowledge gained from pre-test to post-test by the female control group. The bar labeled Chapter 11 Exp M NLG represents the proportion of knowledge gained by the male experimental group, and the bar labeled Chapter 11 Exp F NLG represents the proportion of knowledge gained by the female experimental group. Results including standard error of mean bars show that both the control male and female groups gained almost identical knowledge. In the experimental group, the females scored a slightly higher learning gain from pre-test to post-test. NLG= Normalized Learning Gain)

These findings suggest that gender of the student did not pre-determine whether or not the use of demonstrations aided the knowledge gained in a chapter. The outcomes by gender

for the experimental groups varied from chapter to chapter. However, it is important to note that sample sizes were very small making it more difficult to find any pattern of significance. More in-depth studies would need to be made in order to determine whether or not gender plays a key role in the effectiveness of demonstrations.

Based on the results of the study, a trend was observed suggesting that the students who witnessed the demonstrations did better on post-test compared with the students that did not. However, when broken down by gender, no trend was observed. The results vary from chapter to chapter and gender to gender.

Conclusions

Based on the results of the study, demonstrations in the classroom did make a difference in the learning gains of students in some of the chapters. All students came into each chapter with a similar amount of prior knowledge and those that witnessed the in-class demonstrations consistently did better on the post-tests. One exception to higher post-test scores would be those scores in Chapter 1. The experimental group did not do as well as the control group did on the post-test. This difference indicates that my Chapter 1 pre-test/post-test was possibly not a good assessment, and/or the students were not yet comfortable with the idea of a pre-test/post-test. Though no statistical significance was seen in the Chapter 6 control and experimental groups, a suggested trend was detected showing that the experimental group scored higher on the post-test than the control group. Also, more understanding was acquired based on the normalized learning gain for the experimental group compared to the control. Even though no statistical significance was found in the raw score means for both Chapters 10 and 11, a statistical significance was observed in the normalized learning gain for the experimental groups. This indicates that the demonstrations witnessed within those two chapters were helpful to the students understanding of the material.

I also analyzed the raw score means and normalized learning gains of males versus females in this study. I found that when comparing the two genders, there was no specific trend pointing to one gender being more successful than the other when using demonstrations or not using demonstrations. In one chapter the males in the experimental group did slightly but not significantly better than the females comprising the experimental group. The same was observed when comparing the males and females in the control groups of the same chapter. In

the next chapter the females in the experimental group did better than the males but again not significantly. Similar results were observed with the control groups within the same chapter. These types of results were seen throughout all four chapters when comparing the data by gender. The outcomes could be due in large part to such small sample sizes. By breaking the groups up into males and females, the samples sizes dropped roughly to half of what they were when comparing just the scores in the control and experimental.

When relating my results with those of others studies, differences and similarities were found. Like the other studies cited I did have significance in my results, though I only had significance in two of the four chapters. All of the studies I came across found significance in the units or chapters included in their studies. One difference in my study versus other studies is very few were conducted at the high school level. In fact, I only came across two that were conducted within the last decade. In both of those high schools, the student population was made up of a single gender (Erlis & Subramaniam, 2004; Rade, 2009). Both of these studies found significance when comparing the use of demonstrations compared with no demonstrations. When I broke my study down by gender I was not able to get significant differences. This may be due to smaller numbers of males and females to work with per chapter or just based on social differences at a single-gender school compared with a co-ed school.

If the study could be performed again, one thing I would like to modify is to be more considerate of the questions asked on the pre-test/post-test. If most of the questions are difficult, it becomes challenging to really measure how much understanding the students gained. The students seem to focus on how “hard” the question is or they “don’t understand” what is being asked, and therefore give up answering the questions based on their ability and

comprehension of the topic being addressed. I would also probably include an alternate chapter in place of Chapter 1. While the students did have an opportunity to "practice" taking a pre-test/post-test on review material presented before Chapter 1 began, they appeared to be so overwhelmed to be in a chemistry class that I sensed there were some intimidation issues involved. I also felt there was a lack of comfort early on with the pre-tests and post-tests. I sensed If they had more time to acclimate to chemistry class, i.e., class expectations, idea of pre-tests and post-tests, etc., the students may have been more successful even if my test questions were difficult. Something else I would also add to my study would be the inclusion of a questionnaire to survey my students' opinions of demonstrations using a Likert scale. This would give me the opportunity to get a better gauge of the students' opinions of the inclusion of demonstrations into a chapter.

If this study could be expanded, increasing the number of students in order to get a larger sample size should be considered. Within each chapter, I was working with less than 100 students. Smaller numbers reduced the power of my analysis. Also including different schools and teachers could give insight into how different teacher's approaches to the demonstrations affect students' understanding of the topics tested. Even though the teachers would be following demonstration guidelines, it would be interesting to see how their individual personalities play a part in student learning. This could also be something examined by an opinion survey using a Likert scale. The study of demonstrations should furthermore not be limited to just chemistry as it was in my study. With budget cut woes facing all subjects nation-wide at all levels of education (Dillon, 2011), demonstrations should be considered for all sciences as well as other subjects.

Something else I would like to note deals with the statistical significance observed in this study. Both Chapters 10 and 11 were the chapters that normalized learning gain was found to be significant. These are both chapters that I had the opportunity to do a “pilot run” with during the previous school year. This could suggest that I performed the demonstrations and explanations of those demonstrations better due to more familiarity with them, and consequently the students got more out of them. Because I worked on the chapters previously, I also had a better idea of how to modify my pre-tests and post-tests to more specifically question the topics involved in the chapter demonstrations. If Chapters 1 and 6 had also been a part of the previous year’s practice, I may have seen similar statistical significance in the learning gains as I did in Chapters 10 and 11.

It can also be argued that raw mean scores were not higher overall on the pre-tests and post-tests because not all students gave their best attempt. This could be attributed to maturity of the students (chemistry is primarily a 10th grade class at my school), distractions that individual students were facing on the day of the pre-test or post-test or even just a lack of concern in general academically. A food incentive was provided to keep the students invested in the pre-tests and post-tests (as in Vargo, 2012). Still, a change in my incentives could counteract some of these issues. I did not give any points for my pre-tests and post-tests. I would consider a participation grade or even a bonus opportunity in the future. However, with students and humans in general there will always be some issues with this type of study no matter what the incentive. It is impossible to get 100% participation 100% of the time.

My own impression of the study was that demonstrations kept students more engaged during the class period as well as more inquisitive. Students in the experimental groups asked

more questions during the demonstrations than those in the control group did during the standard lecture. Students also seemed to enjoy the demonstrations continually asking if and when they would get to see one. There was class-wide disappointment when no demonstration was going to be observed. This in itself was a huge encouragement to me as to the usefulness of demonstrations. I will definitely take the knowledge I have gained from the past two years of work and incorporate more demonstrations into my classes. I will not limit myself to only the four chapters I studied, but I will add more demonstrations each year until hopefully I have several demonstrations for each chapter. I also plan on taking the information I have obtained from my study to the administration at my school. Demonstrations are something that can be implemented into all grade levels (elementary and up) and, therefore I will be encouraging my colleagues to implement it into their classrooms.

References

Bowen, C. & Phelps, A. (1997) Demonstration-Based Cooperative Testing in General Chemistry: A Broader Assessment-of-Learning Technique. Journal of Chemical Education 74:6, 715-719

Davis, R. et al. (2009) Modern Chemistry, Orlando, Austin; Holt, Rinehart and Winston

Dillon, S. (2011) "Tight Budgets Mean Squeeze in Classrooms" The New York Times 6 March 2011: nytimes.com Web. 24 May 2013

Erlis, B. & Subramaniam, R. (2004) Use of Chemistry Demonstrations to Foster Conceptual Understanding and Cooperative Learning Among Students. Unpublished paper presented at the International Association for the Study of Cooperation in Education, Singapore.

Exam View Software (2009) FSC Creations Inc, United States: Holt, Rinehart and Winston

GraphPad Instat (2009) GraphPad Software, San Diego California, Unites States, www.graphpad.com

Herr, N. & Cunningham, J. (1999) Hands-On Chemistry Activities with Real-Life Applications San Francisco, Jossey-Bass

Knox, W. (1936) The Demonstration Method of Teaching Chemistry. Journal of Chemical Education 13:166, 166-171

Mazzolini, A. et al. (2011) The Use of Interactive Lecture Demonstrations to Improve Students' Understanding of Operational Amplifiers in a Tertiary Introductory Electronics Course. Latin American Journal of Physics Education 5:1, 147-153

McKee, E. et al. (2007) Effects of a Demonstration Laboratory on Student Learning. Journal of Science Education Technology DOI: 10.1007/s10956-007-9064-4, 395-400

Meyer, L. et al. (2003) Using Demonstrations to Promote Student Comprehension in Chemistry. Journal of Chemical Educations 80:4, 431-435

Pierce, D. & Pierce, T. (2007) Effective Use of Demonstration Assessments in the Classroom Relative to Laboratory Topics. Journal of Chemical Education 84:7, 1150-1155

Rade, A. (2009) The Effectiveness of Lecture Demonstrations to Enhance Learning of Chemistry. Chemistry Education in the ICT Age DOI: 10.1007/978-1-4020-9732-4_16, 145-151

Shakhashiri, B. (1983) Chemical Demonstrations A Handbook for Teachers of Chemistry Madison, WI University of Wisconsin Press

Slater, S. et al. (2010) Discipline-Based Education Research A Scientist's Guide United States; W.H. Freeman and Company

Taylor, C. (1988) The Art and Science of Lecture Demonstration Bristol, England, Adam Hillger

Vargo, A. (2012) The Effect of Extrinsic Rewards in The High School Classroom. M.N.S. Thesis. Louisiana State University. United States of America

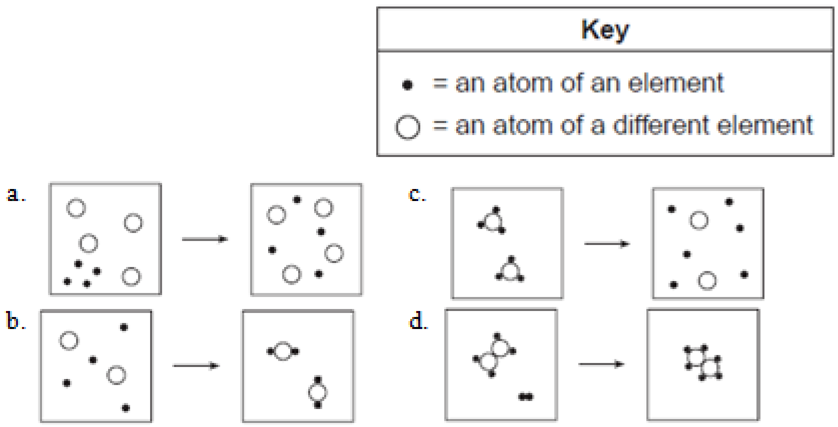
Venneman, S. et al. (2009) Cheap But Not Too Dirty the Value of Chemistry Demonstrations in Teaching Neuronal Physiology to Psychology Majors. European Journal of Social Science 12:1, 123- 130

Appendix A
Chapter 1 Pre-Test and Post-Test Example Questions

____ 11. Which of the following is an example of a homogeneous mixture?
a. air
b. orange juice
c. italian dressing
d. rocky road ice cream

____ 12.

Which diagram represents a physical change, only?



Appendix B
Chapter 6 Pre-Test and Post-Test Example Questions

____ 1. If two covalently bonded atoms are identical, the bond is

a. nonpolar covalent.
b. polar covalent.
c. dipole covalent.
d. coordinate covalent.

____ 2. If the atoms that share electrons have an unequal attraction for the electrons, the bond is called

a. nonpolar.
b. polar.
c. ionic.
d. dipolar.

____ 15. Which lewis dot diagram represents a molecule having a nonpolar covalent bond?

a. 

b. 

c. 

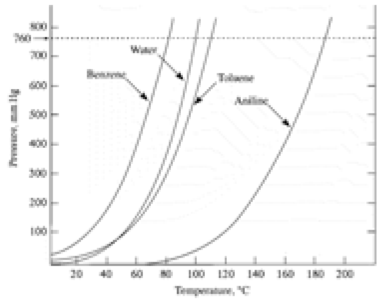
d. 

Appendix C
Chapter 10 Pre-Test and Post-Test Example Questions

____ 13. The density of a substance undergoes the greatest change when the substance change from a

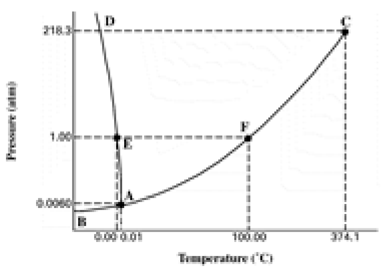
a. liquid to a gas.
b. liquid to a solid.
c. solid to a liquid.
d. a molecular solid to an ionic solid.

____ 14. According to the figure below, what is the most volatile substance shown?



a. benzene
b. water
c. toluene
d. aniline

Use the figure below to answer the following questions.



15. What does point A represent in the figure above?

a. Triple Point
b. Freezing Point
c. Boiling point
d. Conensation Point

Appendix D
Chapter 11 Pre-Test and Post-Test Example Questions

____ 13. The ideal gas law is equivalent to Boyle's law when
a. the number of moles and the pressure are constant.
b. *R* equals zero.
c. the pressure is 1 atm.
d. the number of moles and the temperature are constant.

____ 14. The value of *R*, the ideal gas constant, can be calculated from measured values of a gas's pressure, volume, temperature, and
a. molar amount.
b. chemical formula.
c. rate of diffusion.
d. density.

____ 15. If a gas with an odor is released in a room, it can quickly be detected across the room because it
a. diffuses.
b. is dense.
c. is compressed.
d. condenses.

Appendix E
IRB Approval, Parental Consent and Child Assent Forms

Application for Exemption from Institutional Oversight

LSU
Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu
lsu.edu/irb

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

– Applicant,Please fill out the application in its entirety and include the completed application as well as parts A-F, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://research.lsu.edu/CompliancePoliciesProcedures/InstitutionalReviewBoard%28IRB%29/item24737.html

– A Complete Application Includes All of the Following:
(A) Two copies of this completed form and two copies of part B thru E.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtraining.com/users/login.php)
(F) IRB Security of Data Agreement: (http://research.lsu.edu/files/item26774.pdf)

1) Principal Investigator: James V. Moroney **Rank:** Professor

Dept: Biological Sciences **Ph:** 578-8561 **E-mail:** btmoro@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each
*If student, please identify and name supervising professor in this space

Jessica L. Shelton, College of Science, Graduate Student, 225-445-2420,
jessica.shelton@parkviewbaptist.com
Supervising Professor: James V. Moroney

IRB# E6001 LSU Proposal #
Complete Application
Human Subjects Training

3) Project Title: Louisiana Math and Science Teacher Institute

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 6/17/2015

4) Proposal? (yes or no) No **If Yes, LSU Proposal Number**

Also, if YES, either
○ **This application completely matches the scope of work in the grant**
OR
○ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students) Middle school and high school students

*Circle any **"vulnerable populations" to be used**: (children <18, the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature **Date** 6/1/12 (no per signatures)

**** I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted √ Not Exempted Category/Paragraph

Reviewer Mathews **Signature** **Date** 6/15/12

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 6/12/2015

Parental Permission Form

Project Title: "Using Demonstrations in Chemistry Class to Improve Concept Retention and Understanding"

Performance Site: Parkview Baptist High School

Investigator: Jessica Shelton Parkview Baptist Science Department Faculty Master's of Natural Science Degree Candidate at Louisiana State University 225-205-9449

Purpose of the Study: To determine whether the use of demonstrations during class will help students better understand a concept and recall the facts pertinent to the concept.

Inclusion Criteria: All College Prep chemistry during the 2012-2013 school year

Exclusion Criteria: None

Description of the Study:

Many high school chemistry students struggle with remembering and understanding key concepts in chemistry class. This causes many students great difficulty and anxiety. As a means to improve the students' retention of these concepts and their ability to understand them, I will use demonstrations pertinent to the topics being taught in order to show the students what is occurring chemically.

Two classes will be chosen randomly to act as the control group. These classes will all be taught the same chemistry chapter without any teacher demonstrations or labs used throughout the chapter. The other three sections of chemistry classes will be the experimental group. They will be taught like the control group, but will have classroom demonstrations inserted throughout the chapter. Each student will be given a pre-test of conceptual questions developed from questions provided by the textbook company software before any of the chapter is taught. After the chapter is complete a post-test will be given before the chapter test. The questions on the post-test are identical to those used on the pre-test. Pre-test and post-test scores will be compared statistically uses a p-test to determine whether or not demonstrations aided students understanding of the material taught.

Another chapter will be taught using the same methodology as the previous paragraph described. However, this time the three sections that acted as the experimental group will be the control group and the two sections that were the control group will be the experimental group. This will allow me to treat all of the sections as both experimental and control. Again a p-test will be used to statistically determine the effectiveness of demonstrations in my classroom.

Benefits: The goal of this study is to improve students' ability to retain and understand the concepts taught in a high school chemistry class.

Risks: There are no known risks.

Right to Refuse: All students will be assigned the same material and grades used during the school year. Participation in the study results is voluntary. A student will have the right to withdraw or a student's parent will have the right to withdraw their student from the study at any time without penalty.

Privacy: Results of the study may be published, but no names or identifying information will be included for publication. Subject identity will remain confidential unless disclosure is required by law.

Financial Information: There is no cost for participation in the study, nor is there any compensation to the subjects for participation.

Signatures:

The study has been discussed with me and all of my questions have been answered. I may direct additional questions regarding study specifics to the investigator. If I have questions about subjects' rights or other concerns, I can contact Robert C. Matthews, Chairman, Institutional Review Board, (225) 578-8692, irb@lsu.edu, www.lsu.edu/irb. I will allow my child to participate in the study described above and acknowledge the investigator's obligation to provide me with a Signed copy of this consent form.

Parent's Signature:______________________________ **Date:**________________

The parent/guardian has indicated to me that he/she is unable to read. I certify that I have read this consent form to the parent/guardian and explained that by completing the signature line above he/she has given permission for the child to participate in the study.

Signature of Reader:______________________________ **Date:**________________

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 6/12/2015

Child Assent Form

I, ____________________________, agree to be in a study to observe demonstrations in chemistry class to improve concept retention and understanding . I can decide to withdraw from the study at any time without getting in trouble.

Child's Signature:______________________________ **Age:**________ **Date:**__________

Witness*:____________________________________ **Date:**______________

*(N.B. Witness must be present for the assent process, not just the signature by the minor)

Vita

Jessica Langlois Shelton was born to Larry and Nancy Langlois, in 1981 in Baton Rouge, Louisiana. She attended Kindergarten through 12th grade at False River Academy graduating Salutatorian in 2000. The following fall she attended Louisiana State University where she majored in Biological Sciences. She received her Bachelor of Science in December 2004. Jessica began her career in education in 2007 at Parkview Baptist School where she taught middle school girls' bible, 6th grade life science and high school chemistry. She entered Louisiana State University Graduate School in June of 2011 and is a candidate for the Master of Natural Science degree. She is currently teaching chemistry at Parkview Baptist School in Baton Rouge, Louisiana.