

DIGITAL DATA COLLECTION AND ANALYSIS: WHAT ARE THE EFFECTS
ON STUDENTS' UNDERSTANDING OF CHEMISTRY CONCEPTS

by

Clinton Keith Swartz

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Clinton Keith Swartz

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ABSTRACT

In this project, digital data collection and analysis methods were implemented to determine their effects on student understanding of chemistry concepts, data analysis and conclusion making skills, and motivation. Teacher attitude and motivation were also determined. The students included in the project were from a 10th grade chemistry class, which included 25 students. Students completed a non-treatment unit in which data collection and analysis were completed without the use of technology. Digital data collection and analysis were then added to experiments and class activities during two treatment units. The digital data collection and analysis tools included data collection interfaces and probes, graphing software and simulations. The non-treatment unit and treatment units were then compared to determine the effectiveness of the intervention. Students understanding of chemistry concepts, data analysis and conclusion making, and motivation increased slightly after the treatment units. Teacher attitude and motivation also showed an increase. This project showed that the use of digital data collection and analysis has positive effects on both the students and the teacher.

INTRODUCTION AND BACKGROUND

Integration of technology into the classroom is a point of emphasis in education. This is a key component in teaching students 21st century skills that will make them more marketable in their future career path. As the push for technology integration became greater, I started to reflect on ways that I could introduce technology into my chemistry classes. I wanted to look for ways that would have the greatest impact on my students' education. I pondered the most important aspects of chemistry and science in general. The answers I came up with were data collection and analysis. This, I thought would be an excellent place to introduce technology into my lessons.

The purpose of this project is to improve students' understanding of concepts and to increase their motivation in the chemistry classroom. This was accomplished by introducing digital data collection and analysis tools into daily lessons. The digital data collection and analysis tools included data collection software and probes, graphical analysis software, and web-based simulations. Using these collection and analysis methods students will be able use different forms of technology that are used regularly in science related fields.

Data collection and analysis are fundamental skills necessary for successful scientific research. As a science educator, I believe it is imperative to develop the skills needed to be a successful scientist. Using digital data collection and analysis software, students will be introduced to technology used in the science field. Students are becoming increasingly technologically adept and expect teachers to increase the use of technology in their classes. This project will increase the use of technology and

hopefully motivate students to perform better in chemistry class. Parents and administrators will find value in the project because it will increase the student's use of science related technologies. This project will meet the need for increased use of technology and innovative analysis of data.

The main focus question for the project is: what are the effects of using digital data collection and analysis on students' understanding of chemistry concepts? The project also focused on the following sub questions: what are the effects of using digital data collection and analysis on student motivation and attitude; what effect does using digital data collection have on students' data analysis skills and conclusion making; what are the effects of using digital data collection and analysis on teacher motivation and attitude?

The students taking part in the project are students in my Chemistry I classes at Midd-West High School. The Midd-West School District is a small, rural school located in western Snyder County, Pennsylvania. The Chemistry I class is a first year chemistry course and a graduation requirement. Students are in 10th grade and are heterogeneously grouped in the classes. There are some students who are identified as having learning disabilities and some are identified as gifted students.

The members of my support team included Mindy Callender, Judy Buranich and Cynthia Hutchinson. They provided support and feedback and served as editors on the research project. My MSSE capstone project advisor was Jewel Reuter. My MSSE capstone reader was Terrill Paterson.

CONCEPTUAL FRAMEWORK

A review of recent literature shows that student understanding, motivation, and conclusion making increases when digital data collection and analysis tools are used in the science classroom. These digital technologies can include microcomputer-based laboratory tools, computer simulated laboratory exercises, and web-based archived data. The literature helped to show the improvements in students' understanding of concepts, motivation and data analysis.

Studies have shown that increased student understanding of concepts occurs when digital technologies are used in the science classroom. According to Thornton and Sokoloff (1990), students in a college introductory physics class who use microcomputer-based laboratory (MBL) tools showed larger increases in understanding and retention of science concepts as compared to those who were taught in lecture based classes. In a similar study, Redish, Saul, and Steinberg (1996), were able to show that replacing a one hour lecture based problem solving class with a one hour active-engagement tutorial using MBL tools, increased student achievement on a multiple-choice test in an introductory mechanics class at the University of Maryland.

The use of simulations is another area of digital data collections that has positive effects on student achievement. These simulations allowed students to observe science situations that are normally impractical or impossible (Steinberg, 1999). Students in an introductory physics class at the University of Maryland who completed simulations instead of actual scientific experiments showed increases in understanding of concepts, thinking and reasoning skills (Finkelstein et al., 2005; Kahn, 2010; Steinberg, 1999,

Tolentino et al., 2009). Zacharia and Anderson (2003) also showed increases in the conceptual knowledge of physics concepts in college physics students when simulations were used prior to laboratory experiment.

The use of web-based archived data can also help to improve the retention and understanding of science concepts. It is, at times, impossible to conduct real-time data collection needed to complete an experiment. Web-based archived data can be used when constraints are too great to complete the data collection process. These data have been collected by other researchers and then posted in formats available for students. The students can then use the data to conduct data analyses that would otherwise be too time consuming (Ucar & Trumble, 2011). Dori and Belcher (2005) showed that freshman students in an undergraduate physics class at MIT, showed significant improvement in their understanding of physics concepts. The average scores from the pretest to the posttest increased significantly. High-achieving students mean score increased from 60% to 83% on the pretest and posttest respectively, while the comparison group mean score only went from a 57% to a 61%.

Previous research shows that student motivation increases when digital tools are utilized in their science classes. When students are using various forms of digital tools, they are able to take full ownership over the learning process. This can help motivate them to learn when using the new methods (Tolentino et al., 2009). Students are more engaged when using digital technologies. Engagement can come from the ability to manipulate variables in multiple ways and then observe those changes (Khan, 2010). They are free to collaborate with other students and can help each other to formulate

answers or solve problems (Steinberg, 1999). Collaboration is increased due to the immediate feedback provided by digital data collection tools. These tools allow students to instantaneously discuss problems or unexpected results with each other. This collaboration introduces students to the way scientists conduct research (Thornton & Sokoloff, 1990).

Student data analysis and conclusion making is another area of focus in my research project. According to Dori and Sasson (2006), student's graphing skills and conclusion making improved significantly when students were introduced to a computerized chemistry laboratory environment. They also showed improvement in their abilities to sketch predictive curves based on descriptions of the events. Improvement was shown in all student academic levels, with low performers showing the highest improvements. Students who were using computer simulations in their science classes also showed a marked improvement on scientific predictions, hypothesis, and conclusions (Zacharia & Anderson, 2003; Khan, 2010). Findings from Finkelstein et al. (2005) showed students who completed a computer simulated circuit lab were better able to answer questions that required conclusions being made from the experiments than those students who completed the lab using real equipment. This was related to the students being able to observe microscopic details in the simulations. Significant gains were also obtained in conclusion making when student had to find similarities and differences between two graphs (Dory & Sasson, 2006).

The role of teacher can be transformed when digital technologies are added to the classroom. This change in role can have an impact on teacher motivation and attitude. The effect of implementing digital technologies on teacher motivation and attitude is the

final question in this research project. The study by Tolentino et al. (2009) showed the evolution in the student and teacher relationship when a computer simulation of a titration lab was introduced into the class. The 10th and 11th - grade students took full control over the activity while the teacher took a secondary role. This allowed the teacher to take the role of discussion and reflection facilitator. The instructor still has control to help guide the student learning. When using simulations, the teacher still has control over the variables in the simulation. This limits the students for seeing unwanted changes and also allows the students to “mess about” and still have productive learning (Finkelstein et al., 2005, p. 5). Implementing these changes would impact my role as an educator from more of a directing role to a facilitating role. These studies showed the changes that may occur and they may better prepare me for these new roles.

The impact of digital technologies on student learning is well documented. Increases in students’ understanding of concepts, motivation, and data analysis skills and conclusion making are possible when digital technologies are implemented in the classroom. Changes in teacher motivation and classroom role can also occur when digital technology is introduced in the classroom. The increases in student understanding, motivation and analysis skills can be significant and the implementation of digital technologies will be beneficial.

METHODOLOGY

Project Treatment

Students will complete a non-treatment unit completing laboratory experiments and classroom activities without the use of digital data collection and analysis. During the treatment units, the students will complete experiments and classroom activities with the use of digital data collection and analysis tools.

The non-treatment unit focused on periodic trends and how physical and chemical properties can be determined based on those trends. The non-treatment unit was taught using my normal classroom procedures. Students completed pre and post unit assessments to show their level of understanding of concepts. Students were taught the basic concepts through the use of PowerPoint presentations, worksheets, and problem sets.

To facilitate the learning of the periodic trend concepts, laboratory experiments and activities were completed. In these activities there was no use of digital data collection or analysis tools. After an introductory lesson on the periodic trends, a graphing activity (Appendix A) was completed. In this activity the students produced graphs, which showed the relationship between the atomic number and the properties of atomic radius and ionization energy. Once they completed the graph, they answered questions that analyzed the graphs. The graphs were then discussed in class to show how the trends actually increase or decrease both across the periods and down the groups.

Next, the students completed an experiment (Appendix B) that examined the relationship between density and the period number. Students determined the density of three Group IV metals using water displacement. The density was determined from the

volume, found using the water displacement, and the mass of the metal samples. A graph was produced showing the relationship between the density and the period number.

These graphs were then used to determine an experimental density of germanium, which was compared to the actual value. As an extension to the experiment, students produced two more graphs in which they were to graph density against two other properties, like atomic mass or atomic number. Again they used the graphs to determine an experimental density of germanium. They then compared the results from the three graphs to determine which gave the best approximation of the density of germanium. After the activity, the students discussed the outcomes gained from the experiment and the produced graphs.

The first treatment unit focused on ions and ionic compounds. Students examined the topics of ions, ionic compounds, ionic bonding, and unit cells. For the treatment unit, students will complete laboratory experiments and class activities using digital data collection and analysis tools. Students began the first treatment unit learning about the formation and properties of ions and ionic compounds. Main concepts were taught with the use of PowerPoint presentations and classroom activities. After an introductory lesson on ionic compounds, students were given data to graph the steps in the formation of an ionic compound against the potential energy. They were allowed to use computers to develop the graphs. They then answered questions about the formation of an ionic compound. These graphs were used to show the students that in the formation of most ionic compounds energy is being released.

Students then completed a lab in which they observed the conductivity of ionic compounds dissolved in solution. In the experiment, three groups of solutions were

tested with the conductivity probe to determine their conductivity. The probe determined a conductivity value for each of the solutions, which was read by the computer. High conductivity values resulted from large quantities of ions being present in the solution. Low conductivity values showed low concentration of ions in the solution. From these data, the students determined which solutions were formed from ionic compounds. They determined the relationship between the conductivity and the type of compound found in the solution.

An experiment in which students determine the empirical formula of an ionic compound by completing precipitation reactions was completed. Two solutions were mixed in different ratios to produce different quantities of precipitants. The amount of precipitant was determined and then plotted on a graph against the volume ratio of reactants to determine the empirical formula. Students produced the graphs using graphing software and evaluated the graphs to determine the empirical formula.

The second treatment unit focused on covalent bonds and covalent compounds. Students will begin learning about covalent bonds and what types of covalent bonds can be formed. The students completed two graphing activities in which they determined the relationship between bond energies and the types of covalent bonds formed. In the first activity, students graphed the electronegativity difference of various hydrogen halide compounds versus the bond energy. Once they graphed the data, they determined the relationship between the electronegativity and the bond energy. In the second activity, students graphed the bond energy vs. the bond length. They produced a scatter plot and then looked to determine the best-fit straight line of the data. The students then completed a set of questions that required them to look for the correlation between bond

length and bond energy. Both graphs were produced and analyzed using graphing software.

A brief lesson on intermolecular forces was completed to introduce the students to other forces that bond substances together. An experiment that investigated the relationship between evaporation and intermolecular forces was then completed. The students used temperature probes that were connected to the computer interface and observed the temperature change that occurred when a substance evaporated. The temperature change was recorded for different alkanes and alcohols. The temperature change was then used to determine the strength of either the hydrogen bonding or the dispersion forces present.

Students then completed a lab simulation in which they built different molecules. In this simulation, they built molecules and then determined type molecules formed, types of bonds present, and the shape of the molecules. After building the molecules, they recorded the shape, the types of bonds and the number of single and double bonds. Next, they drew the Lewis-structure of the molecules. They then answered questions about the shapes of the molecules and the bonds present.

The final section of information to be covered in the treatment unit was the valence shell electron pair repulsion theory. A PowerPoint presentation will be used to deliver beginning information to the students. The students used an online molecular modeling simulator to determine the geometry of various compounds. They built different compounds, drew the Lewis-structures, and then determined the valence shell electron pair repulsion theory geometry of the compound. The simulation activity is found in Appendix C.

Data Collection Instruments

The students in the project are students in the Midd-West High School. Midd-West High School is a small, rural school in western Snyder County, Pennsylvania. The total enrollment of the district in 2010-2011 was 2202 students. The demographics of the school district are: 97.2% of the students are white, 1.8 % are African American, 0.8% are Hispanic and 0.3% are Asian. There are a total of 652 students enrolled in the high school. All 25 students in the project are members of my heterogeneously grouped 5th period Chemistry class. Students range in ability level with some labeled as gifted and some having a learning disabilities. There are 14 female students and 11 male students in the class with 99% of the students being white and 1 % being African American.

The data triangulation matrix shown in Table 1 shows the relationship between the data collection instruments and the research questions. The data sources will effectively show the effects of the intervention on the students' performance and motivation. Data collection occurred during both the non-treatment and treatment units.

Table 1
Triangulation Matrix

Research Questions	Data Source 1	Data Source 2	Data Source 3
What effect does using digital data collection and analysis have on students' understanding of chemistry concepts?	Pre and post unit assessments with concept questions (Non-treatment and treatment)	Laboratory summaries (Non-treatment and treatment)	Student interviews with concepts maps. (Non-treatment and treatment)
What effects does using digital data collection and analysis have on students' data analysis skills and conclusion making?	Laboratory summaries (Non-treatment and treatment)	Student surveys (Non-treatment and treatment)	Student interviews
What effect does using digital data collection and analysis have on students' motivation and attitude?	Student surveys (Non-treatment and treatment)	Post unit student interviews (Non-treatment and treatment)	Teacher observation with guide
What effect does using digital data collection and analysis have on teacher motivation and attitude?	Teacher weekly reflections	Peer observation	Student interviews

Data collection methods used to determine the effects of digital data collection and analysis on student understandings of concepts were pre and post unit assessment questions for both the treatment units and the non-treatment unit, laboratory summaries, and student interviews. The non-treatment unit assessment (Appendix D) and two treatment unit assessments (Appendices E and F) were completed before and after each

unit and helped to determine percentage gains in understanding among students. The students completed laboratory summaries (Appendix G) after the completion of an experiment. These helped to assess students' understanding of concepts by determining their ability to relate knowledge learned in class with the information gained during the experiment. Six students were selected to be interviewed: two high-achieving students, two average-achieving students and two low-achieving students. The interviews are found in Appendices H and I. The same six students were interviewed throughout the project. During the interviews, students were given key terms to complete a concept map, which they then explained. They were then interviewed with the questions found on the interview sheet.

Student data analysis skills and conclusion making were evaluated by using the pre and post unit assessments, laboratory summaries, and student interviews. The laboratory summaries will be used to determine the conclusions made by the students during the experiments. Student interviews and surveys will be used to determine student thoughts on their analysis skills and conclusion making skills.

The effects of digital data collection and analysis on student motivation and attitude were determined by using student surveys, interviews, and teacher observations. The student surveys (Appendix J and K) were given to the students to complete before the non-treatment unit and after the treatment units. The same six students were interviewed about their motivation and attitude toward the treatment and non-treatment units. Teacher observations during the laboratory and class activities will also be used to determine student motivation. The teacher observation guide is found in Appendix L.

The combination of student input and my observations allowed the motivation of the students to be fully determined.

Teacher motivation was determined by using teacher weekly reflections, peer observations, and student surveys. The weekly reflections (Appendix M) helped to assess my attitude and motivation toward implementing data collection and analysis tools during chemistry class. The peer observations were completed weekly during laboratory activities. The observer used the form found in Appendix N as guide during the observations. The observations focused on my interactions with the students during the experiments. Student surveys were used to assess the students' feeling toward my motivation and attitude change. These showed the students' perception of my attitude and motivation change.

The various forms of quantitative and qualitative data were used to determine the effects of digital data collection and analysis tools have on students and teacher. These data were analyzed to determine the differences between the non-treatment and treatment units. A timeline showing the implementation of the project can be found in Appendix O. The timeline is broken down into the non-treatment unit and the two treatment units. It shows the activities that were completed as part of the project. Also, the timeline displays when the various data collection methods that were performed.

DATA AND ANALYSIS

Data were collected to determine the effects of digital data collection and analysis on students' understanding of chemistry concepts. Data from a non-treatment unit and two treatment units were collected and triangulated. The data was analyzed and compared

to determine the effects of the treatment units. The data collection methods used were pre-unit and post unit assessments, laboratory summaries, and student interviews with concept maps.

Pre-unit and post unit assessments were given for the non-treatment unit and the two treatment units. The percent change was determined so a comparison between the units could be completed. The data from the non-treatment unit and the treatment units are located below in Table 2. Both the treatment and the non-treatment showed considerable improvements in students' understandings. The treatment units did show higher overall percent changes with an overall increase of 6.2 percentage points in students understanding of concepts over the non-treatment unit.

Table 2

Average Scores of Non-treatment Unit and Treatment Units Pre-unit and Post unit Assessments (N=25)

Data Source	Non-treatment Unit	Treatment Units
Pre-unit Average	35.5 %	34.3%
Post unit Average	84.3%	83.6%
Percent Change	137.5%	143.7%

A comparison between the non-treatment unit, treatment unit 1, and treatment unit 2 helped to clarify the percent change differences between the units. The data are presented in Table 3. The overall percent change average for the treatment units showed larger increases in student understanding of concepts than the non-treatment unit. When looking at each treatment unit, treatment unit 1 showed a greater increase than treatment unit 2. This was probably due to the fact that the information for treatment unit 2 was more closely related to the information from the non-treatment unit. This would have increased the students' prior knowledge on the material resulting in the higher pre-

assessment scores. The pre-assessment average for treatment unit 1 was the lowest of the three units and lead to largest gain in student understanding. For all of the pre-unit assessments, many students either didn't answer many of the questions or only partially answered the questions. This was most likely due to the difficulty of the material and a lack of prior knowledge of the information being learned.

Table 3

Average Scores of Non-treatment Unit, Treatment Unit 1 and Treatment Unit 2 Pre-unit and Post unit Assessments (N=25)

Data Source	Non-treatment Unit	Treatment Unit 1	Treatment Unit 2
Pre-unit Average	35.5 %	30.7%	37.8%
Post unit Average	84.3%	83.6%	85.4%
Percent Change	137.5%	172.3%	125.9%

Post assessments for the three units were all relatively similar with treatment unit 2 having the highest post assessment average. Treatment unit 1 post assessment was the lowest of the three units but it had the highest percent change. This large percent change may be due to less prior knowledge of the information in treatment unit 1. Treatment unit 2 and the non-treatment unit had the closest related material, which likely caused the post assessment average of treatment unit 2 to be the highest. The lower percent gain for treatment unit 2 was likely due to the higher amount of information gained from the non-treatment unit.

Pre-unit and post unit assessments were also analyzed to determine their effects on students of differing achievement levels. Students were grouped into three achievement levels, high, average, and low. These data are shown below in Figure 1. The low-achieving students showed the greatest percent changes out of the three groups.

Their percent changes for both treatment units increased over the non-treatment unit. The average-achieving group showed the next highest percent changes but treatment unit 2 had a lower percent change than the non-treatment. The high-achieving students had the lowest percent changes, which were likely caused by their already high achievement level.

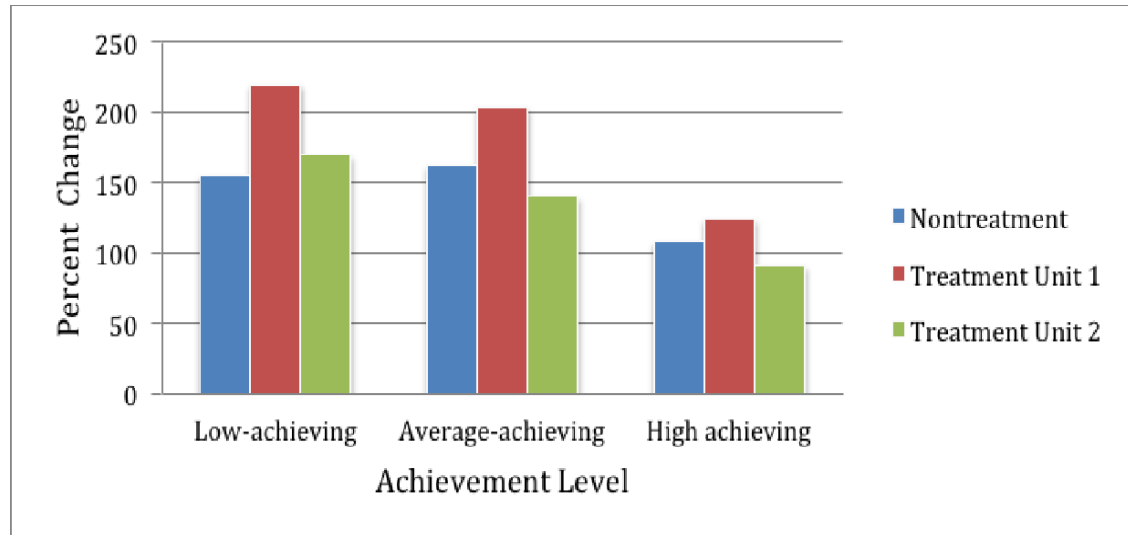


Figure 1. Average percent change for pre and post unit assessments for high-achieving, average-achieving and low-achieving students, (N=25).

Laboratory summaries were also used to assess the students' understanding of concepts. The summaries were given after the labs were given and the students had to use the results to answer the questions. The data for the laboratory summaries are presented below in Figure 2.

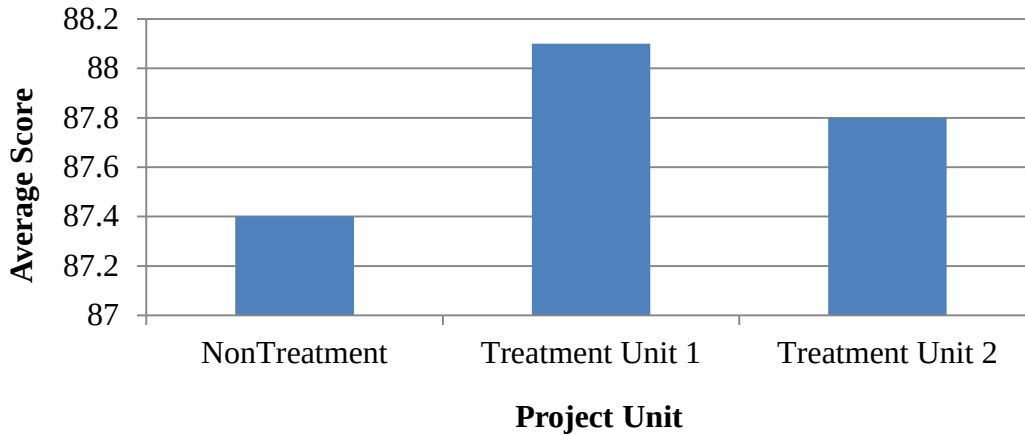


Figure 2. Average scores for the laboratory summaries, ($N=25$).

The findings from the laboratory summary data are similar to finding from the pre-assessments and post assessment data. These data indicate the use of digital data collection and analysis improved students' understandings of concepts. During the non-treatment unit, students collected the data and analyzed without the use of technology. Graphs and data tables were produced manually and then students analyzed the data to determine the trends that were present. In the treatment units, data were collected electronically and students could produce graphs and analyze the data through the use of computer software. The data during the treatment units were easily collected and students could focus on the experiments and didn't have to worry about data collection. This could have helped increase their scores on the laboratory summaries because they had better understanding of how the data related to the experiment. Also, having better scaled and more accurate graphs would give the students a better understanding of how the data related to the information learned in class.

Student interviews with concept maps were the final method used to determine gains in students' understanding of concepts. The data collected showed similar results as the other collection methods. The data are shown below in Table 4. The treatment

units showed higher scores on the concept maps than the non-treatment unit. The second treatment unit showed the highest increase in the average score for the concepts maps. Treatment unit 2 dealt with covalent compounds and covalent bonding. Much of the information was similar or related closely to the non-treatment unit, which was on periodic trends. Many of the connections in the concept map for treatment unit 2 are based on the trends of electronegativity and ionization energy, which are learned in the non-treatment unit. This would have enabled the students to make better connections and better explain the concept maps.

Six students were interviewed and constructed concepts maps for the both the non-treatment and treatment units. Two students were selected from high-achieving, average-achieving and low-achieving student groups. The high-achieving students and the average-achieving students scored higher or equal to the non-treatment score during the treatment units. During the interview a high-achieving student stated, "The use of the computers and the data analysis helped me to learn concepts better." An average-achieving student commented that "it was easier to learn concepts when we used the simulations which showed the molecules moving." One low-achieving student had a lower score in treatment unit 2. The other low-achieving student scored higher during both the treatment units. A common theme that all the students interviewed shared was that they felt they learned better when completing experiments. The integration of digital data collection added to their overall learning of chemistry concepts. Overall the data indicated that the intervention increased students' understandings of chemistry concepts

Table 4
Concept Map Scores for Non-treatment and Treatment Units (N=6)

Student	Non-treatment	Treatment Unit 1	Treatment Unit 2
HA 1	7	8	9
HA 2	8	9	8
AA 1	7	7	8
AA 2	6	6	7
LA 1	4	4	3
LA 2	4	5	6
Average	5.8	6.5	6.8

Note. In the table above the HA1, HA2, AA1, AA2, LA1, and LA2 represent 2 high-achieving students, 2 average-achieving students and 2 low-achieving students.

Data were collected and analyzed to determine changes in students' data analysis skills and conclusion-making abilities. Laboratory summaries, surveys and interviews were used to collect the data. The scores for the laboratory summaries are located in Figure 2. The laboratory summaries were given after experiments were completed. Responses from the students relied heavily on their ability to analyze the data and to make conclusions. The students scored higher on the summaries in both treatment units when compared to the non-treatment unit. Students scored higher on the treatment unit 1 summaries when compared to the treatment unit 2 summaries. The experiment completed during treatment unit 1 were more quantitative in nature and the data collected tied more directly to the conclusions gained from the experiments. In treatment unit 2, some of the experiments dealt more with molecular shapes or used models to have students determine the molecular shape of covalent compounds. The quantitative nature of the experiments in treatment unit 1 may have led to the higher scores in the laboratory

summaries during since students would have had the data direct link with the data and the conclusions. Also, the data found in the treatment unit 1 experiment were manipulated mathematically to find various results, which could have led to an increase in the students' ability to analyze the data and make conclusions.

One of the questions on the survey collected data on the students' thoughts on how the class activities affected the conclusion-making abilities. These data are below in Figure 3. According to the student responses, all three units had very close responses. Both treatment units have the same average response of 4.3. The non-treatment unit average response was 4.2. While there is a slight increase in student responses when comparing the two treatment units with the non-treatment unit, the change is small. Looking at the average response by the students for all three units shows an interesting trend. For all three units, the students agreed that the class activities helped their conclusion making abilities. This is an important finding since part of the focus deals with collection of data and data analysis. The students agreed that the collecting data and analyzing the data either manual or with the use of technology increased their conclusion making abilities.

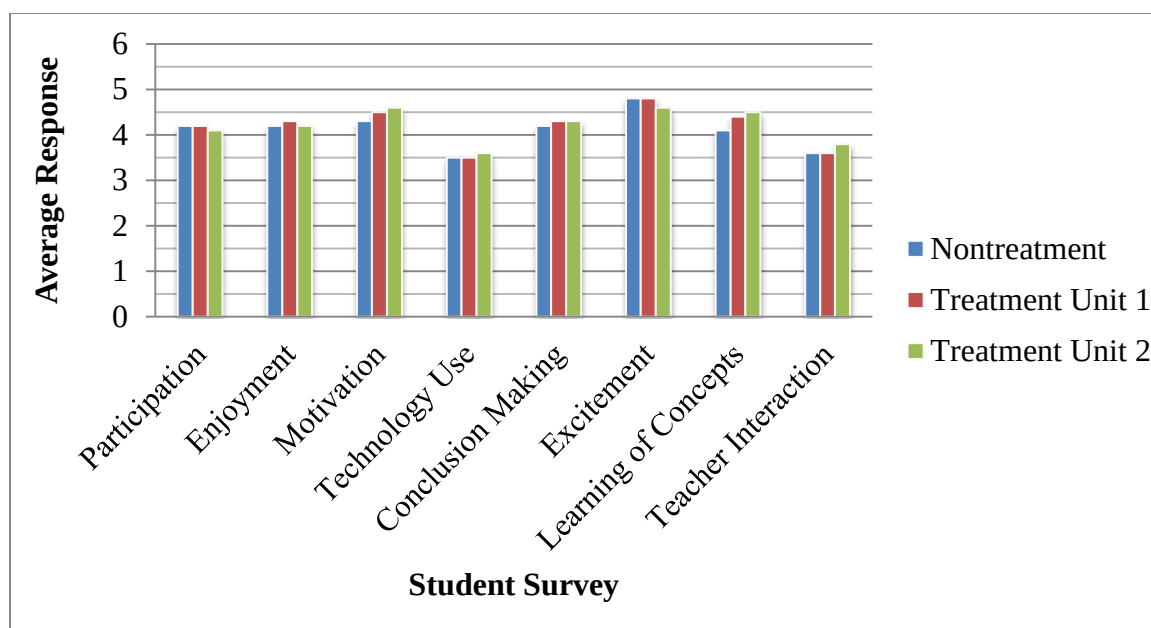


Figure 3. Average student responses to selected survey questions, (N=25).

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree.

Students were interviewed to evaluate how they felt the non-treatment and treatment units affected their conclusion-making and data analysis skills. A common theme that evolved from the interviews was that all the students believed that it was easier for them to analyze the data when they made graphs. More specifically, the students all agreed that they could better analyze the data when they produced the graphs electronically. The students noted that they could get better results from the computer-graphed data because their data points were plotted more accurately. A high-achieving student commented, “gaining information from the computer generated graphs was much easier because the computer automatically set it up for us.” This would also help the students make better conclusions from the data because they are not changing the results by incorrectly plotting the data. Also, using the graphing software allows the students to have the computer determine the best-fit line and slope. These pieces of information can be useful in determining the objectives of the lab. According to a low-achieving student,

“I didn’t have to worry about messing up the calculations and getting the wrong answer. The computer did it for me and then I could get the answer right.” Having the students analyze the data with computers helps to show their improvements in conclusion making and data analysis skills. You can focus specifically on the skills instead of whether they can produce a graph correctly. Overall, the various data indicated that the intervention slightly increased students’ conclusion-making and data analysis skills.

Student motivation and attitude increased during the two treatment units when compared to the non-treatment unit. Teacher observations were recorded during each of the experiments during the non-treatment and treatment units. The data can be found below in Figure 4. Student participation in labs increased in the two treatment units. Treatment unit 2 showed the highest student participation of all three units. Notes from the observations show more student engagement during the experiments in the two treatment units. Students appeared to be more on task and were less distracted during the treatment units. During the non-treatment unit students had to be directed back to the task more often than during the treatment units. This typically occurred during the data analysis portion of the experiments. This can be correlated to the idea that the students were more engaged when using technology than when completing the analysis manually. Interestingly, the average response from the student surveys did not show an increase during the treatment units. In fact, treatment unit 2 had the lowest score of the three units according to the student survey. An explanation for this could be that the students completed the survey at the end of the unit. Also, their idea for the scoring could be different than the teacher. It is still positive that the students agreed that they were motivated during all the units. During the interviews the students generally agreed that

they were motivated to complete the activities during all three units. They all liked being able to complete experiments and do hands-on activities. An average-achieving student commented, “I liked to be able to do the experiments and collect actual data. I wanted to do the work because I was creating the results.” The use of technology to collect and analyze the data also increased the motivation of the students. A high-achieving student said, “I wanted to do the experiments because we were able to use equipment that we are used to using.” This comment shows the desire of students to use the technology that they used during the intervention. This is important because scientists collect and analyze data during their experiments using these technologies.

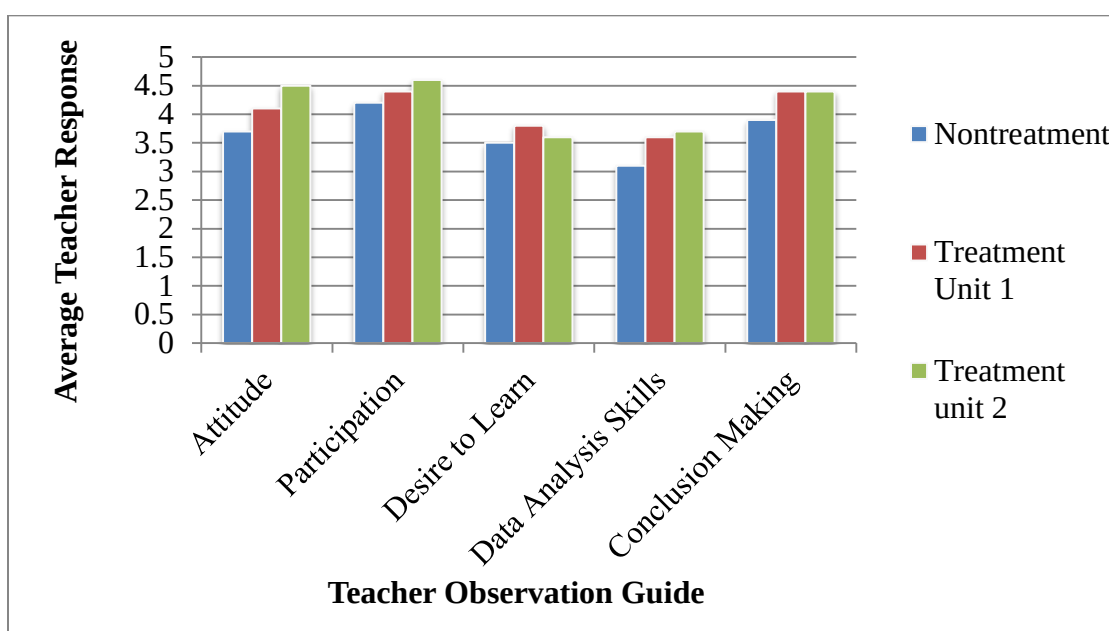


Figure 4. Average teacher response to observation guide questions, ($N=3$).

Note. Likert Scale 5 = high to 1 = low

Student attitude also increased during the treatment units. Treatment unit 2, again, showed the highest average attitude score from the teacher observations, found in Figure 4. Students were more positive during the treatment unit experiments than during the non-treatment unit. Many students complained during the non-treatment unit

experiments about having to collect the data by hand. The students reinforced this during the interviews. Most of the students commented that it was easier to use the data collection tools and made the experiments more enjoyable. The data collected from the student surveys did not help to clarify the comparison between the non-treatment unit and the treatment units. The average student response for questions pertaining to excitement and enjoyment of the experiments were highest for the treatment unit 1. Treatment unit 2 average responses were lower than the non-treatment unit. The lower score for treatment unit 2 may be a result of the nature of the experiments completed during that unit. Simulations were used instead of experiments for the student to collect data. This may have led to a decrease in enjoyment for that unit. Both the non-treatment and treatment unit 1 utilized more traditional hands-on experiments.

My weekly reflections were used to determine my attitude and motivation of during the non-treatment and treatment units. Figure 5 shows the average response from the teacher weekly reflection. My attitude toward the data collection methods was higher during the treatment units. During the reflections, I commented that I felt the data collection methods used during the treatment units were more beneficial to the students than during the nontreatment units. The use of the graphing software was an area that I believed was important for the students to use. This led to the increase in my motivation for using the digital data collection methods. My attitude towards the students was higher during the treatment units. Treatment unit 1 being the highest of the three units. My attitude toward the students shows my feelings about the amount of work completed, attention to the details of the experiments and the amount of help needed. According to comments in my weekly reflection, students during all three units did a

decent job at working on the experiments, staying on task and only needing a little help to complete the experiments. They did a slightly better job during the treatment units, especially during treatment unit 1. This led to my increased attitude towards the students because they were more independent during the experiments and stayed on task more. The students seemed more engaged when using the digital data collection and analysis methods and were able to work through their own problems during the experiments. Students during treatment unit 2 were able to use internet simulations to collect data and analyze it. Some students had difficulties staying on the simulation site and ventured on to other sites. I had to redirect them back to the correct site on occasions which decreased my attitude towards them. This caused the scores for treatment unit 2 to be lower than the treatment unit 1.

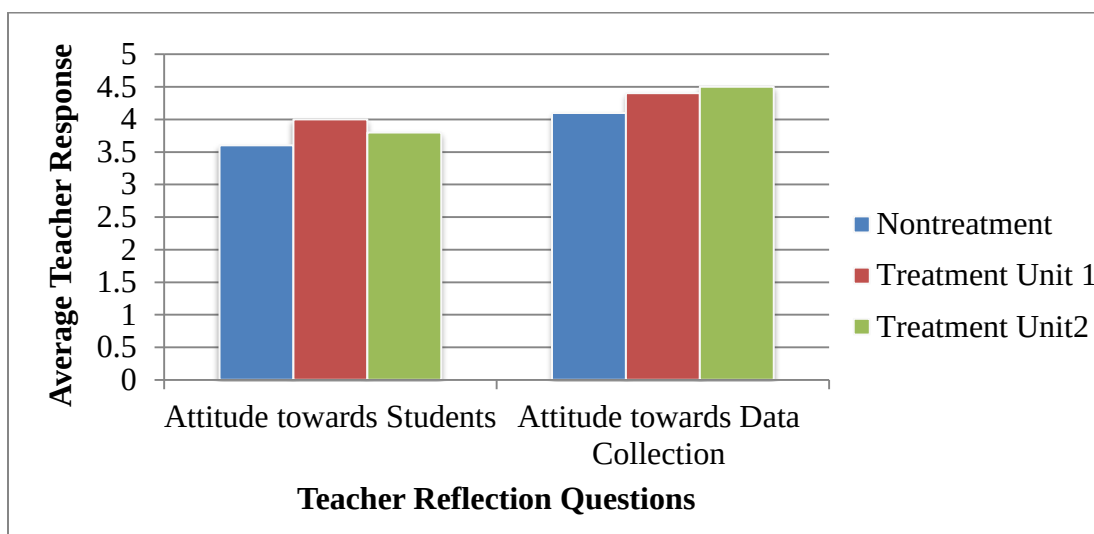


Figure 5. Average teacher response to weekly reflection questions, (N=3).

Note. Likert Scale 5 = high to 1 = low.

Mindy Callender, who is my neighboring teacher and the other chemistry teacher, completed the peer observations. Her observations show an increase in teacher motivation and attitude during the treatment units. Her observations show a higher

average response during the treatment unit 2. Many of her notes from treatment 2 commented that I visited each group and answered questions from the group. Also, when asked questions by the students, I didn't just give them the answer but directed them towards the answer. During treatment unit 1, Mindy noted that the students worked independently and were engaged during the experiments. Only slight adjustments to the work being completed by the students were necessary from the teacher. She noted that teacher and student interactions were high during all the units. I have always tried to interact with all the students during regular class time and lab time. It was exciting to see that she noticed this and it validated something I believed in.

INTERPRETATION AND CONCLUSION

The data gathered during this project were analyzed to determine the effects of digital data collections and analysis on students understanding of concepts, conclusion making and data analysis skills, motivation. Teacher motivation and attitude was also examined during the project. The data showed that students make slight gains in learning of chemistry concepts when using digital data collection and analysis methods. The gains were small but there were gains in all data collections methods between the non-treatment and treatment units. The low-achieving students showed the greatest gains in the understanding of chemistry concepts. This suggests that adding digital data collection and analysis tools to regular classroom activities could lead to positive gains in the achievement of chemistry students. Conclusion-making and data analysis skills also increased throughout the project. The students took a more active and engaged role in the experiments during the treatment units. This helped them derive better conclusions from

the data. The use of data collection devices allowed the students to focus more on the analysis of the data. This allowed them to get better data-points and ultimately more accurate results from the experiments.

Student motivation and attitude also increased through the use of digital data collection and analysis methods. Student feelings toward completing an experiment compared to regular class activities. The data suggest that most of the students agree that their motivation to learn, participation and enjoyment of class increases when experiments are completed in chemistry class. This increase also holds true when the students are grouped based on their achievement level. Their increased motivation caused them to work more independently and they remained more focused during the experiments. This greatly helped them to gain better conclusions from the experiments and increased their overall knowledge in chemistry.

My motivation and attitude increased through the use of digital data collection and analysis tools. Introducing the students to the equipment and the wealth of tools that go with the equipment really seemed to spark some interest with the students. I observed the students becoming more engaged and taking the learning into their own hands. That was very exciting for me to see and made me want to keep adding these tools to my lessons. With the digital data collection and analysis tools, you can focus the students more on the data and analysis. I used to spend more time going over how to collect the data, organize it and then interpret it. The tools used in the project simplified that and allowed me to see what they could do with the data and not worry about them incorrectly collecting it.

There are some aspects of the project that I would change. Without time constraints, I would have changed the timing of the project. The units of material that I was covering at the time of the project weren't the most experiment-orientated units. It would have been a little easier to find experiments that included digital data collection and analysis if the time line could have been different. In the future, I would also try to select three units of material that are not related to each other. This would ensure that students have a more level baseline of knowledge throughout the project. I also would have worked through a survey with the students before using a survey to gather data. Most students didn't complete the sections that asked them to explain their answer. Also, it seemed that many students had the same response for each question. They may have just chosen that response to quickly finish the survey. Working through a survey and going over the question on a trial run may be beneficial to help them understand the questions and better answer the responses in the future. Finally, I would have been more specific with the laboratory summary questions. I would make the questions more specific to the experiment that they are completing. I would have been able to get more specific answers and clearer data to analyze.

VALUE

This study helped to show that student achievement, motivation, and attitudes increased when digital data collection and analysis tools are implemented in a chemistry class. They showed positive gains in the learning of chemistry concepts when compared to a non-treatment unit. The students are more likely to participate in the activities and enjoyed the class more when digital data collection and analysis tools were used. This

has positive implications for the students who tend to come to science class with the belief that science is boring and does not apply to their lives. The results of the study have motivated me to increase the use of digital tools during both experiments and normal classroom procedure. One area of focus will be to use these technologies outside and apply the chemistry concepts learned in the classroom with the world outside the school. Adding these technologies to existing lessons and experiment would not be difficult to accomplish. The positive impacts these changes would have on the students make the changes worthwhile. These will hopefully keep the students interested in the course material and improve their learning in the class.

Teachers of other subjects can use this study to improve achievement and to motivate students in their classes. There are many digital tools that can be utilized in other subject areas. Math teachers can implement the use of graphing software to help students both produce graphs and then analyze the graphs to draw conclusion. The results of the study are also significant to show that the students are learning and are motivated to learn 21st century skills through the use of digital data collection and analysis tools. Many of these tools are found and used in the colleges and industry. Administrators would need to find ways to help find funds for the equipment. They could look for ways to acquire donations or grants to get equipment into the schools. Many schools already have grant writers who work to acquire funds for the schools. They could also ask local businesses or science related companies for donation of equipment or money. All science classes and many other subject areas, like math, history, and psychology can utilize the equipment.

This study helps to show the importance of including digital data collection and analysis tools in the science classroom. A possible extension of this study would be to link inquiry activities with the digital data tools. I have been trying to implement more inquiry activities into my classes but none of them focus on the data collection or analysis. Both types of activities influence students' learning of chemistry concepts so it would be an excellent way to improve student learning. They would get the benefit of having to determine how to get the results and then use the technology to analyze the data.

This study impacted my beliefs as a science educator greatly. I always wanted to add more technology into my classes but didn't really know how to accomplish it. This study highlighted an easy and productive way to increase the use of technology in my lessons. This increased my motivation to both implement and search for new ways to add digital data collection and analysis tools into my course materials. They are effective at increasing students understanding of chemistry concepts and motivate the students to become better scientist.

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APPENDICES

APPENDIX A

PERIODIC TABLE GRAPHING ACTIVITY

Trends in the Periodic Table
Chemistry

Name _____

Date _____ PD _____

Purpose: To determine the trends if they exist, for atomic size and ionization energy in the Periodic Table.

Materials:

Worksheet
Graph Paper

Procedure:

1. Use the information from the section of the periodic table. Be sure to give each graph a title and to label each axis.
2. For elements 3-20, make a graph of atomic radius as a function of atomic number. Plot atomic number on the X axis and atomic radius on the Y-axis.
3. For elements in Family 1(1A) and Family 2 (2A), graph period number vs. atomic radius. Use a different color or symbol for each line.
4. For elements 3-20, make a graph of ionization energy as a function of atomic number. Plot atomic number on the X-axis and ionization energy on the Y-axis.
5. For elements in Family 1(1A) and Family 2 (2A), graph period number vs. ionization energy. Use a different color or symbol for each line.

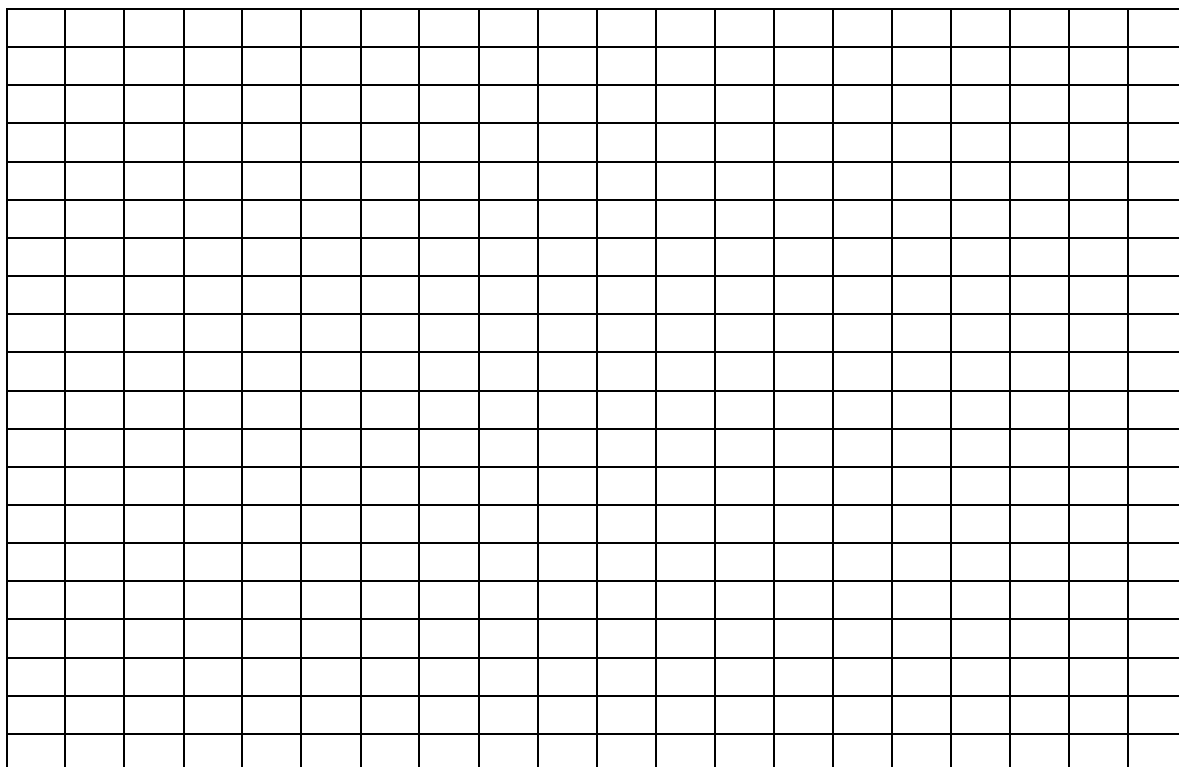
	1 (1A)	2 (IIA)	13 (IIIA)	14 (IVA)	15 (VA)	16 (VIA)	17 (VIIA)	18 (VIIIA)
2	3 Li 1.23 124	4 Be 0.89 215	5 B 0.80 191	6 C 0.77 260	7 N 0.70 335	8 O 0.66 314	9 F 0.64 402	10 Ne 0.67 497
3	11 Na 1.57 119	12 Mg 1.36 176	13 Al 1.25 138	14 Si 1.17 188	15 P 1.10 242	16 S 1.04 239	17 Cl 0.99 299	18 Ar 0.98 363
4	19 K 2.03 100	20 Ca 1.74 141						

5	37 Rb 2.16 96	38 Sr 1.91 131				8 O 0.66 314	ATOMIC SYMBOL ATOMIC IONIZATION	NUMBER RADIUS ENERGY
6	55 Cs 2.35 90	56 Ba 1.98 120						

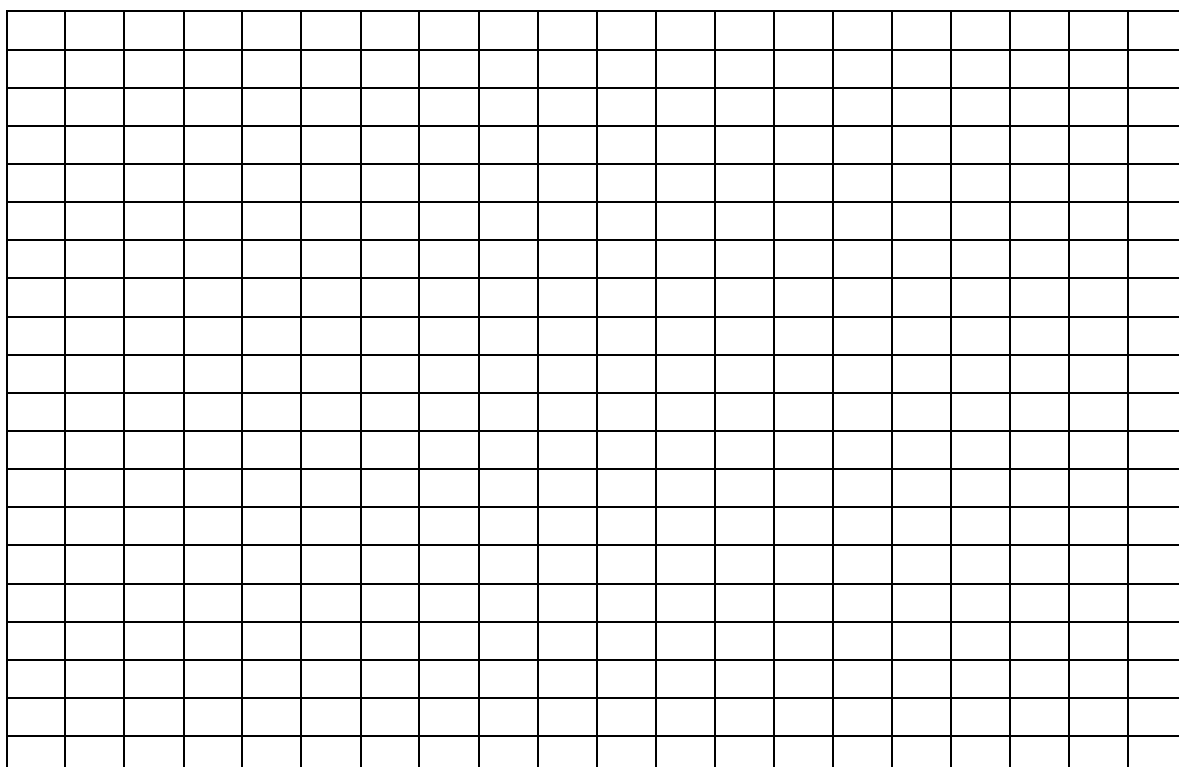
1. Atomic Radius vs. Atomic Number

A blank sheet of graph paper featuring a uniform grid of small squares. The grid consists of 20 columns and 20 rows, creating a total of 400 square units. The lines are thin and black, set against a white background. There are no margins, text, or other markings on the page.

2. Period Number vs. Atomic Radius



3. Ionization Energy vs. Atomic Number



4. Period Number vs. Ionization Energy

A full-page sheet of white graph paper featuring a uniform grid of thin black lines. The grid consists of 20 columns and 20 rows, creating a total of 400 small squares. The lines are evenly spaced and extend across the entire page, leaving no margins or additional markings.

Analysis

1. What happens to the atomic radius as the atomic number increases across a period? Why?
2. What happens to the atomic radius as the atomic number increases down a period? Why?
3. What happens to the ionization energy as the atomic number increases across a period? Why?
4. What happens to the ionization energy as the atomic number increases down a family? Why?

Conclusion:

1. Looking at the graph, explain the peaks and troughs of atomic radius.
Hint: Think about electron configuration.
2. Looking at the graph, explain the peaks and troughs of ionization energy.
Hint: Think about electron configuration.

APPENDIX B

DENSITY EXPERIMENT

Density: A Periodic Property

Purpose

The purpose of this experiment is to measure the mass and volume for three Group IV metals. The density of the metals is calculated from this data and then used to determine the density of germanium.

Materials

Lead Shot
Silicon Lumps
Tin Shot

Electronic Balance
100 mL graduated cylinder

Procedure

1. Obtain about 8 grams of silicon and measure the mass on an electronic balance. Record the value in the data table.
2. Fill a 100 mL graduated cylinder with about 30 mL of water. Record the actual value of the water in the data table.
3. Slowly add the silicon to the graduated cylinder until the water level rises about 1ml.
4. Measure and record the final volume of the water in the data table.
5. Measure and record the mass of the remaining metal in the data table.
6. Pour out the water and dry the metal before returning it to the container.
7. Repeat steps 1-5 for twice for the remaining amounts of the solid. There should be three sets of volume and mass data for the metal.
8. Obtain about 25 g of tin shot. Record the actual mass in the data table.
9. Repeat steps 2-7 for the tin. Record all the data in the data table.
10. Obtain about 35 grams of lead shot. Record the actual mass of the metal.
11. Repeat steps 2-7 for the lead shot. Record all data in the data table.

Data Table

Element	Sample	Initial Mass (g)	Final Mass (g)	Mass of Solid (g)	Initial Volume (mL)	Final Volume (nL)	Volume of Solid (mL)
Silicon	1						
	2						
	3						
Tin	1						
	2						

	3						
Lead	1						
	2						
	3						

Questions and Analysis

1. Using the mass and volume data, calculate the density of each sample 1-3 for all three elements. Construct a table to display the density results.
2. Calculate the average value of the density calculation for the three elements.
3. ON a graph plot the period number of the tine, lead and silicon on the x-axis and the density on the y-axis. Using a ruler draw a best-fit straight line to predict the density of germanium.
4. Look up the actual density of germanium and then calculate the percent error between the predicted and actual values.
5. Pick two other properties to graph against the density to try and predict the density of germanium. Again draw a best-fit straight line predict the density of germanium.

References

Flinn ChemTopics Laboratory Manual 4. Flinn Scientific 2003.

APPENDIX C

VSEPR GEOMETRY ACTIVITY

Molecular Geometry Report Sheet

Molecular formula	Lewis structure	Electron-group geometry	Bond angle	Molecular geometry	Sketch	Polar or nonpolar ?
Example molecule: CH ₄						
CH ₄	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $	tetrahedral	109°	tetrahedral		nonpolar
The first 5 molecules are listed as examples on Table 1. Use these as practice to make sure you understand how to use the model kit and how to visualize the molecular geometry before you attempt the remaining molecules.						
CO ₂						
BF ₃						
CCl ₄						

Molecular formula	Lewis structure	Electron-group geometry	Bond angle	Molecular geometry	Sketch	Polar or nonpolar ?
NH ₃						
H ₂ O						
SCl ₂						
I ₃ ⁻						
SO ₂						

Molecular formula	Lewis structure	Electron-group geometry	Bond angle	Molecular geometry	Sketch	Polar or nonpolar ?
ICl_4^-						
AsF_5						
IF_4^+						
H_3O^+						
TeF_5^-						

Molecular formula	Lewis structure	Electron-group geometry	Bond angle	Molecular geometry	Sketch	Polar or nonpolar ?
HCN						
IOF ₅						
BrF ₃						
SO ₄ ²⁻						
CO ₃ ²⁻						

APPENDIX D

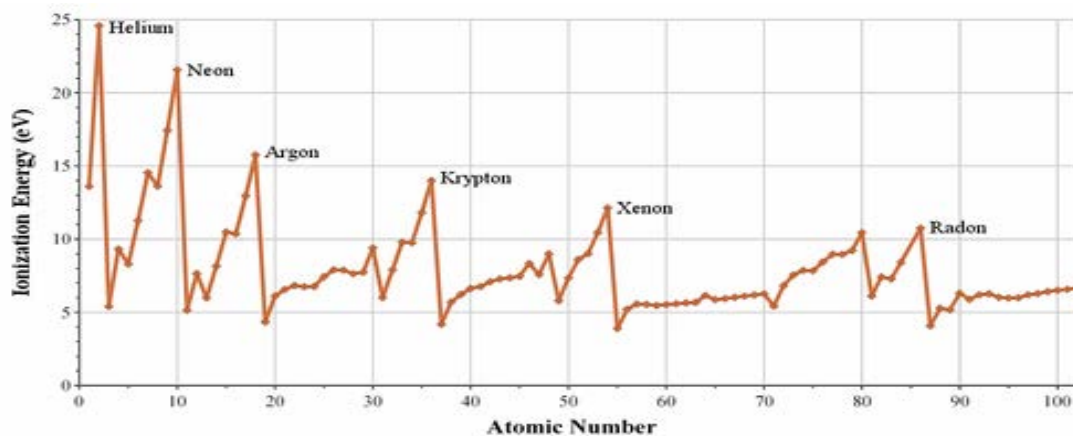
PRE/POSTUNIT ASSESSMENT: NONTREATMENT

Periodic Table Preassessment

Name: _____

Answer the following questions in complete sentences.

- 1) What is the basis for the trends found on the periodic table?
- 2) How can we use electronegativity to determine the type (ionic or covalent) of compound that will be formed between elements?
- 3) Explain the reasoning for the increase in atomic radius as you move down the groups.
- 4) Why is the first ionization for an element with multiple electrons lower than the second ionization energy?
- 5) Use the following graph to answer the question.
What is the trend for ionization energy with respect to the atomic number and the period number? Use examples from the graph in your answer.



APPENDIX E

PRE/POSTUNIT ASSESSMENT: TREATMENT UNIT 1

Ionic Compounds Preassessment

Name: _____

Answer the following question in complete sentences.

- 1) Why are the properties of an ion different than it's parent atom?

- 2) Why do metals tend to form cations while nonmetals tend to form anions.

- 3) Why is lattice energy important to the formation of a salt?

- 4) Most metals are found in nature as an ore or in compounds. Using your knowledge of metals explain why they are not normally found in there elemental form in nature.

- 5) Why do ionic compounds help to conduct electricity when they are dissolved in water?

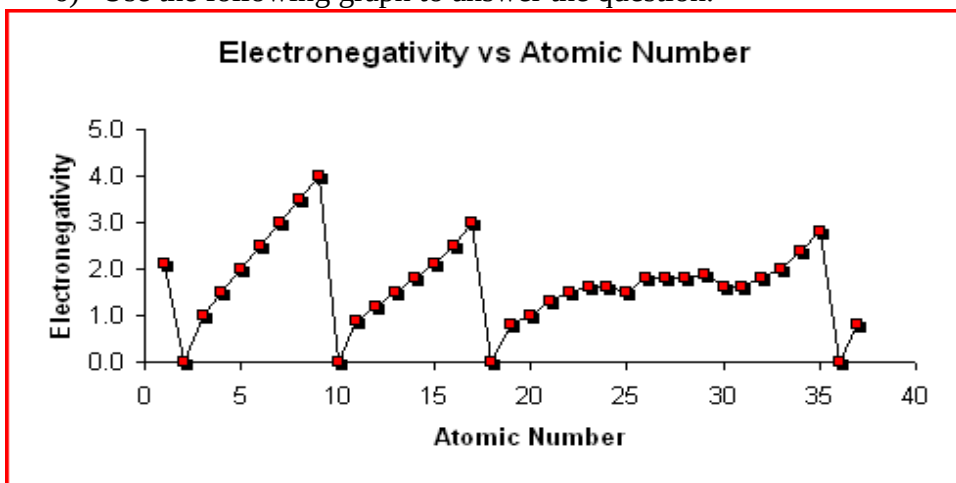
APPENDIX F

PRE/POSTUNIT ASSESSMENT: TREATMENT UNIT 2

Covalent Bond Preassessment

Name: _____

- 1) What are the three types of bonds commonly used to form compounds? Explain how electronegativity differences play a role in the bond type being formed.
- 2) What does a Lewis structure show?
- 3) Draw a Lewis structure for the following compounds:
 - a. PCl_3
 - b. SCl_4
- 4) What does the valence shell electron pair repulsion theory tell us about a covalent compound?
- 5) Determine the shapes of the following compounds using the VSEPR theory:
 - a. PF_3
 - b. CCl_4
- 6) Use the following graph to answer the question.



How does the electronegativity of the difference between metals and nonmetals affect the type of bond being formed?

APPENDIX G

LABORATORY SUMMARY

Laboratory Summary
Chemistry 1
Mr. Swartz

Name: _____

1. What was the purpose of the experiment completed?
2. What were the main concepts being studied in the experiment?
3. What results were found from the experiment?
4. How do the results found reinforce the main concepts being studied in today's experiment?
5. What were three possible errors that occurred during the experiment? How did these errors affect the results of the experiment?

APPENDIX H

INTERVIEW WITH CONCEPT MAP: NONTREATMENT

Concept Map: Periodic Table

Please construct a concept map for the periodic table on the sheet of paper I have given you. Use linking words to show the connection between the words. Use the following terms to construct the map: periodic table, atomic number, elements, periods, groups, atomic radius, ionization energy, and electronegativity. Use the term periodic table to begin your concept map. I will ask you at the end to explain the reasoning behind your concept map.

Interview Questions (pretreatment)

1. Do you enjoy completing laboratory experiments in chemistry class? Explain.
2. What motivates you to learn concepts in chemistry class? Explain.
3. Do you learn better by completing worksheets and homework or by completing chemistry experiments? Explain.
4. Do the laboratory experiments help you connect the concepts with real-world experiences? Explain.
5. Do laboratory experiments make you want to come to chemistry class and learn? Explain.
6. Do you like to collect the data and then construct graphs by hand? Explain.
7. Can you analyze the data easier when it is graphed? Explain.
8. Is it easier to make conclusions from the graphs? Explain

APPENDIX I

INTERVIEW WITH CONCEPT MAP: TREATMENT

Concept Map: Chemical Bonding

Please construct a concept map for the periodic table on the sheet of paper I have given you. Use linking words to show the connection between the words. Use the following terms to construct the map: valence electrons, atoms, ions, ionic compounds, covalent compounds, nonpolar, polar, and Lewis structures. Use the term periodic table to begin your concept map. I will ask you at the end to explain the reasoning behind your concept map.

Interview Questions (treatment)

1. Do you enjoy completing laboratory experiments in chemistry class? Explain
2. What motivates you to learn concepts in chemistry class? Explain
3. Do you learn better by completing worksheets and homework or by completing chemistry experiments? Explain.
4. Do the laboratory experiments help you connect the concepts with real-world experiences? Explain
5. Do laboratory experiments make you want to come to chemistry class and learn? Explain.
6. Do you like to use the computers to collect data and produce graphs? Explain
7. Can you analyze the data easier when it is graphed? Explain.
8. Is it easier to make conclusions from the graphs? Explain
9. Are there any other comments you would like to add? Explain

APPENDIX J

STUDENT SURVEY: NONTREATMENT

Student Survey: Nontreatment

Name: _____

Please complete the following survey as honestly as you can. The answers to the survey will not affect your grade in anyway. This survey is only used to gain information about your feelings towards learning.

The following scale will be used during the survey: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree).

Directions: Circle that number on the scale the best describes your feelings.

- | | |
|---|-----------|
| 1. I participate in class more during experiments. | 1 2 3 4 5 |
| 2. I enjoy completing laboratory experiments in chemistry class. | 1 2 3 4 5 |
| 3. I am more motivated to learn in class when completing experiments?
What caused your increased motivation? | 1 2 3 4 5 |
| 4. The use of technology in class activities helps me to learn concepts better.
What types of technology do you prefer to use? | 1 2 3 4 5 |
| 5. Chemistry experiments help me to make conclusion based on the concepts learned in class. | 1 2 3 4 5 |
| 6. Chemistry class is more exciting when experiments are completed in class. | 1 2 3 4 5 |
| 7. I learn concepts in chemistry class better when completing laboratory experiments.
Explain why you think you learn better. | 1 2 3 4 5 |
| 8. The teacher interacted with me and helped with the completion of the experiment
Explain. | 1 2 3 4 5 |

APPENDIX K

STUDENT SURVEY: TREATMENT

Student Survey: Treatment

Name: _____

Please complete the following survey as honestly as you can. The answers to the survey will not affect your grade in anyway. This survey is only used to gain information about your feelings towards learning.

The following scale will be used during the survey: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree).

Directions: Circle that number on the scale the best describes your feelings.

1. I participate in class more during experiments. 1 2 3 4 5
2. I enjoy completing laboratory experiments in chemistry class. 1 2 3 4 5
3. I am more motivated to learn in class when completing experiments? 1 2 3 4 5
What caused your increased motivation?
4. The use of technology in class activities helps me to learn concepts better. 1 2 3 4 5
What types of technology do you prefer to use?
5. Chemistry experiments help me to make conclusion based on the concepts learned in class. 1 2 3 4 5
6. Chemistry class is more exciting when experiments are completed in class. 1 2 3 4 5
7. I learn concepts in chemistry class better when completing laboratory experiments. 1 2 3 4 5
Explain why you think you learn better.
8. The teacher interacted with me and helped with the completion of the experiment Explain. 1 2 3 4 5

APPENDIX L

TEACHER OBSERVATION GUIDE

Teacher Observation Guide

Laboratory Experiment:

Date:

Data Collection Method:

Student attitude toward experiment:

1 2 3 4 5

Observations:

Student participation in experiment:

1 2 3 4 5

Observations:

Student desire to learn during the experiment:

1 2 3 4 5

Observations:

Student data analysis skills

1 2 3 4 5

Observations:

Student conclusion making:

1 2 3 4 5

Observations:

APPENDIX M

TEACHER WEEKLY REFLECTION PROMPTS

Teacher Weekly Reflection

Date:

Data collection or analysis tools used during the week.

General reflection for the week's activities.

My attitude toward the data collection and analysis methods:

1 2 3 4 5

Comments:

My attitude toward the students:

1 2 3 4 5

Comments:

APPENDIX N

PEER OBSERVATION GUIDE

Peer Observation Guide

Laboratory Experiment:

Date:

Teacher attitude toward experiment:

1 2 3 4 5

Observations:

Teacher/Student interaction during experiment:

1 2 3 4 5

Observations:

Teacher desire to help students during the experiment:

1 2 3 4 5

Observations:

Students interaction with teacher during the experiment:

1 2 3 4 5

Observations:

APPENDIX O

TIMELINE

Capstone Project Timeline

January 9th – Begin nontreatment unit with preassessment and preunit concept interviews
January 11th – Periodic trend graphing activity
January 13th – Teacher reflection
January 16th – Periodic trends: density lab
January 17th - Laboratory summary: density lab
January 19th – Reactivity of alkaline metals lab and peer observation
January 20th – Laboratory summary: reactivity of alkaline metals and teacher reflection
January 24th – Postassessment: nontreatment
January 25th – Student concept interviews and surveys.
January 28th – Begin treatment unit 1: ionic compounds with preassessment
February 3rd – Graphing potential energy of ionic compound formation and teacher reflection
February 7th - Conductivity of ionic compounds lab and peer observation
February 8rd – Laboratory Summary: Conductivity
February 10th – Empirical formula of an ionic compound lab and teacher reflection
February 13th – Laboratory Summary: Empirical formula
February 14th – Postassessment: Treatment Unit 1
February 15th – Student interviews and surveys
February 16th – Begin Treatment Unit 2: Covalent compounds with preassessment
February 21st – Graphing electronegativity vs bond length
February 22nd – Graphing bond energy vs bond length
February 24th – Teacher reflection
February 27th – Evaporation and Intermolecular Attractions Lab
March 1th – Building models simulation and peer observation
March 2th – Laboratory summary: building molecules
March 6th – VSEPR simulation and teacher reflection
March 8st – Laboratory Summary: VSEPR simulation
March 13th – Postassessment: Unit 2
March 14th - Student Interviews and surveys