

THE EFFECT OF SUPPLEMENTAL ONLINE TUTORIALS  
ON CHEMISTRY COMPREHENSION IN STUDENTS  
DIAGNOSED WITH ADHD

by

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DEDICATION

This capstone paper is dedicated to my dear parents, William and Annette Burgess, from whom I have learned the most important lessons in life.

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## ABSTRACT

Students who are diagnosed with Attention Deficit Hyperactive Disorder (ADHD) have difficulty concentrating for extended periods. This population is predisposed to a host of comorbidities with other academically debilitating disorders such as anxiety and daytime drowsiness. This project was designed in order to assist this population of learners in a high school chemistry course. For the first treatment, students watched daily tutorial videos in order to improve comprehension, while also increasing confidence levels and decreasing anxiety. The tutorials explained chemistry concepts and demonstrated how to solve multistep chemistry problems. A second treatment was implemented in which multiple choice quizzes were interspersed throughout the tutorial videos in order to measure whether improved focus could be obtained. Data concluded that the tutorials were extremely successful. The population of ADHD students performed better on formative assessments in addition to increasing their confidence levels and decreasing anxiety levels surrounding the study of chemistry.

## INTRODUCTION AND BACKGROUND

Commonwealth Academy is a college-preparatory school in Northern Virginia designed with the sole mission of educating students with learning differences. The student population is comprised of average to gifted learners who benefit from individualized classes. The average class size at Commonwealth Academy ranges from three to ten students. Many of our students are diagnosed with a learning disability (LD), and a significant population is diagnosed with Attention Deficit Hyperactive Disorder (ADHD). These students have a particularly difficult time maintaining focus throughout the school day, regardless of the small class sizes and individualized attention from faculty.

Many ADHD students take prescription medication to assist with inattention. In most cases, these medicines are extremely effective and allow this population of students to increase their focusing abilities and perform well in their studies. Understandably, these medications are only effective when used properly and taken regularly.

Some students forget to take their medicine before arriving to school, or may forget to take their “lunchtime” dose and therefore lose focus during the afternoon classes. Any number of students may be on a new trial medicine that causes them to lose focus over the course of the school day. In addition, most medicines wear off at a certain time and therefore compromise the focus of the student.

Whatever the reason, this focusing deficit has caused numerous students to miss important details in lectures and laboratories and to fare poorly on assessment and

laboratory grades. This leads to reduced confidence and oftentimes disengagement as a direct result of falling behind in the class.

In an effort to support these students and meet them where they are in this focusing challenge, I created concise, online tutorial lectures that allowed our students to learn when they were most focused. This endeavor did not translate into a fully flipped classroom. The tutorials served as review lectures and the online nature of the tutorials allowed students the freedom to learn and review when they were most focused.

### Focus Question

Based on extensive research, I chose the following question for my action research project: What is the impact of supplemental online tutorials on the comprehension level of chemistry concepts on students diagnosed with ADHD? The following sub questions were also addressed:

*Sub-Question 1:* Does the use of online tutorials increase student comprehension?

*Sub-Question 2:* Does the addition of mid-memory assessments into the online tutorials further increase student comprehension?

*Sub-Question 3:* Does the use of online tutorials decrease anxiety levels and improve confidence levels regarding chemical concepts?

*Sub-Question 4:* How are supplemental videos effective in increasing overall achievement in chemistry?

### CONCEPTUAL FRAMEWORK

Chemistry is a rigorous science course, which requires an immense degree of attentiveness. Students from all backgrounds are susceptible to encountering difficulty

when taking this course. The subject matter encompasses such a broad array of material, from tiny quarks to the expanses of the universe. A lot of material is packed into a year and it can be daunting for any person to hone the skills necessary to learn and pass the course even if one were to have the most intensive focusing abilities. Lectures are such a fundamental component to a study of chemistry. Without the benefit of the teacher's explanations, students can quickly become confused and begin to lose interest.

Studies show that persons with ADHD have trouble sustaining focus for long periods of time (Brown, 2008). In addition, the Diagnostic and Statistical Manual of Mental Disorders (5<sup>th</sup> ed.; DSM-5; American Psychiatric Association, 2013), explains that "ADHD is characterized by a pattern of behavior, present in multiple settings (e.g., school and home), that can result in performance issues in social, educational, or work settings." It includes that, "symptoms will be divided into two categories of inattention and hyperactivity and impulsivity that include behaviors like failure to pay close attention to details, difficulty organizing tasks and activities, excessive talking, fidgeting, or an inability to remain seated in appropriate situations" (American Psychiatric Association, 2013).

Many persons with ADHD take medication in order to alleviate their inattention. Medication has helped numerous students to improve their focus in school. Unfortunately, a variety of factors influences the efficacy of medication. Students often forget to take their medications, or the medication wears off by midday. In some cases, students are on the wrong dosage or type of medication. In each of these scenarios, the

student loses their ability to remain focused and is therefore at risk of missing key information presented in their classes.

In addition to the impact of medication (or lack thereof), students with ADHD have been found to exhibit a level of daytime sleepiness that other students lack. According to a longitudinal study published in the *Journal of Sleep Research*, students diagnosed with ADHD are extremely affected by daytime sleepiness (Langberg, Dvorsky, Becker, & Molitor, 2014). A series of self-reported rating scales were used for the study. Participants self-reported their daytime sleepiness via the Pediatric Daytime Sleepiness Scale at the beginning of the academic year and at the end of the academic year. A baseline and follow up of ADHD symptoms was assessed at the beginning and end of the academic year for comparison. The Behavior Assessment System for Children, 2nd Edition (BASC-2) was used to measure “school maladjustment.” Participants also completed the Barkley Functional Impairment Scale to measure “psychosocial impairment.” Lastly, grade point average (GPA) data was collected from all participants in order to measure academic achievement. It was concluded that daytime sleepiness had a measurable effect on academic performance, specifically on receiving Ds and Fs. Males in particular were found to perform worse, academically, than females. The correlation between daytime sleepiness and poor grades was found to be higher for students averaging <2.0 GPA (Langberg, Dvorsky, Becker, & Molitor, 2014).

It would seem reasonable to conclude that ADHD students would recognize their inefficient focusing abilities and therefore be more adept at self-advocating for

themselves in order to excel in school. Unfortunately, this self-advocating can be impeded by a predisposition to anxiety in this population.

A study performed by Biederman, Newcorn, and Sprich (1991) suggests that persons diagnosed with ADHD are likely to have comorbidity with other disorders, including anxiety disorders. They concluded that “epidemiologic and clinical samples of children with anxiety disorders and children with attention deficit hyperactivity disorder have found a comorbid association between attention deficit hyperactivity disorder and anxiety disorders of approximately 25%” (p. 570). This comorbidity demonstrates an additional struggle that many students diagnosed with ADHD encounter on a regular basis. When a student fails to understand course material, it is impertinent that the student seeks clarification outside of class. It is reasonable to suggest that anxiety can lead to an aversion to self-advocating. For students who are already susceptible to inattention, an anxiety disorder can only lead to more frustration as the student is confronted with an additional obstacle on the path to learning.

Students with ADHD encounter a variety of obstacles in the traditional classroom. From inattention to sleepiness and anxiety, what can be done to assist this population in attaining academic success? One logical solution is online learning. The ability to access academic material online would give students the opportunity to learn when they are most focused. Students would have the ability to stop, rewind, and re-watch these lectures at their own pace in order to solidify concepts.

Much discussion has been made over the years concerning the effectiveness of online learning. With the invention of the Internet and a growing comfortable reliance on

mobile technologies, teachers are now able to provide instruction like never before in the history of education. Students are now able to access course material outside of the classroom and in so doing have completely altered the traditional form of education. The emergence of the flipped classroom is a prime example. In a flipped classroom, students learn the course material in reverse, so to speak. Online lectures and tutorials are viewed for homework and the students return to the classroom to demonstrate comprehension and seek clarification. In one cited study involving calculus students, 59 videos were posted to include a variety of mathematical course content. A tool was used to track the number of times the video podcasts were watched. Surveys were employed to garner student feedback surrounding the videos. The cited studies favored the flipped classroom. The results showed that the majority of students – two-thirds of the participant pool – utilized the video podcasts over a 21-day period. Per the surveys, students were highly favorable towards the video podcasts (Herreid & Schiller, 2013).

Although the flipped classroom is gaining significant traction, many teachers today offer a blend of the flipped and traditional classroom. A growing number of teachers now utilize online tutorials to supplement their live lectures. Studies suggest that this growing trend of blended learning is highly successful. In a 2006 study, a mixture of live and online lectures was presented to students with encouraging results. The study measured the effectiveness of video-recorded lectures among university students who used them over the course of two years. Data documenting the use of video lectures from 1160 students via voluntary surveys was compiled between July 2005 and June 2006 in order to determine the overall usage of the videos. Students from various

school clubs were surveyed via a questionnaire consisting of two main sections: (1) the profile of students, and (2) student feedback regarding the use of video lectures. It was concluded that video-recorded lectures were beneficial for the students who used them. Despite the lean towards online learning, it is interesting to note that the study also concluded that students preferred both traditional lectures and video-recorded lectures in order to increase learning (Soong, Chan, Cheers, & Hu, 2006).

Some may question whether students learn as effectively if they are taught through an online medium. After all, the traditional classroom gives students the opportunity to ask the teacher questions mid-lecture. A study performed by Nikopoulou-Smyrni and Nikopoulos (2010) tested the efficacy of video lectures versus traditional lectures. Five post-graduate students comprising one male and four females between the ages of 25 and 44 were the test participants for this study. Participants were given sixteen, five-minute lectures on two main topics (kinesiology and psychological issues for children) by way of video or traditional means. The video-based lectures were videos of the traditional lectures in order to remove any undue bias due to delivery. Students were assessed using quizzes based on the objectives of each lecture. It was concluded that there was no measurable difference between lectures delivered using traditional or video lectures. At best, the two methods were equal in their effectiveness to achieve comprehension.

Mind wandering is yet another hindrance to learning and it is well worth considering whether the two delivery methods of instruction result in similar mind drifting behavior. Szpunar, Khan, and Schacter (2013) discovered that students have the

tendency to mind wander and lose interest as they watch online content. In order to increase the effectiveness of online lectures and to reduce the mental fatigue associated with viewing them, mid-lecture memory tests were employed in a study performed by Szpunar, Khan, and Schacter (2013). Two experiments were used in which students were given mid-lecture memory tests regarding the online lecture material. Two groups of 80 students were given online lectures with interpolated memory tests. One group was told that they would be formally tested at the end of the online lecture while the second group was told it would be tested intermittently throughout the lecture. The latter group performed better on assessments since they knew they would be tested frequently. Encouragingly, the use of mid-lecture memory tests was also shown to relieve student anxiety surrounding the assessments. In addition, the mid-lecture memory tests kept students focused on the lecture and decreased mind-wandering behaviors, allowing them to take notes and more effectively absorb content.

All of these studies support the idea that online learning is an effective means of educating students but science courses are both challenging and rigorous, and the need for clarification of concepts great. The efficacy of online learning in a science course was studied in 2012 by researchers He, Swenson, and Lents. Supplemental video tutorials were created for students in an analytical chemistry class. The participants consisted of a treatment group and a control group. The treatment group was comprised of 27 second-year undergraduate students who were enrolled in a four-credit analytical chemistry course. The comparison group consisted of students in this class from the past three years. Video tutorials were created in response to student feedback concerning

course weaknesses. Grades from homework and assessments were also reviewed in order to develop specific treatment videos. The video tutorials were then made available to students within five days of the students being assessed formally or informally. Final exam answers of the treatment group were compared to the final exam answers of students from the previous three years. Student surveys were taken in order to receive feedback regarding the video tutorials.

The study determined that video tutorials increased student knowledge by a significant amount. In one aspect of the study, “preparing a solution from a solid reagent,” students increased their assessment scores from 46% to 92%. Student feedback was high concerning the acceptance of video tutorials with 76% asking for more tutorial videos in the course. Overall, it was found that video tutorials were extremely successful in assisting students with challenging science course material (He, Swenson, & Lents, 2012).

All students should have the ability to learn without undue burden. Students with ADHD have specific obstacles to learning that can be alleviated with the addition of online learning. Inattentiveness can lead to gaps in essential information in a standard, traditional class and this deficiency becomes compounded if the course is particularly challenging. The student can begin to feel helpless and unsupported.

Studies suggest that supplemental online learning is beneficial to students and that it is comparable to live learning. It seems reasonable to deduce that online learning be considered a proven support in assisting students who struggle with inattention. Research affirms the efficacy of this online mode of instruction and demonstrates that even

difficult science concepts, like those found in a chemistry course, can be learned with this assistive technology.

Students with ADHD can become better learners with supplemental online technology since they are able to access key information and learn when they are most focused. This population need not worry or become excessively anxious due to missed class material if supplemental lectures are made available online.

### METHODOLOGY

As a teacher at Commonwealth Academy, I felt the need to design a project that would benefit the large population of ADHD students in my chemistry classes. Our school prides itself in having ten or less students per class in order to provide low student-to-teacher ratios. It is for this reason that I used the same fifteen students as comparison, first treatment group, and second treatment group, over the course of three separate but equally challenging chemistry units: ionic compounds, covalent compounds, and polarity. All three units share an equal blend of vocabulary, skill sets, and degree of difficulty.

#### Participants

My participants consisted of fifteen students split into two separate chemistry sections. Each section included an equal blend of sophomores and juniors. The morning section was comprised of six students and the afternoon section was comprised of nine students. Thirteen of the fifteen students are diagnosed with ADHD and take medication, and all fifteen of my students have an Individualized Education Program (IEP) and are given specific accommodations for various learning differences. My school is

approximately seventy percent male, and my class statistics are no different. In the combined sections, there are five females and ten males, equaling a 67% male to 33% female ratio. Twenty-two percent of the students are of Asian and Hispanic descent. Our students come from a higher socioeconomic bracket and all students have access to portable devices such as laptops and iPads necessary for treatment.

### Treatment

My treatments were implemented over the course of three units with the same students. For the comparison unit involving ionic compounds, I gave my students access to daily live lectures, only. For the first treatment unit involving covalent compounds, my students had access to both the daily live lectures and the addition of daily and concise (5 – 15 minutes) supplemental online tutorials with accompanying worksheets. Lastly, for the second treatment unit involving molecular polarity, my students had access to the live lectures, and the supplemental online tutorials with the addition of mid-tutorial quizzes in place of the worksheets. All groups had the same in-class experience, throughout, with typical quizzes and a formal assessment given at the end of the unit.

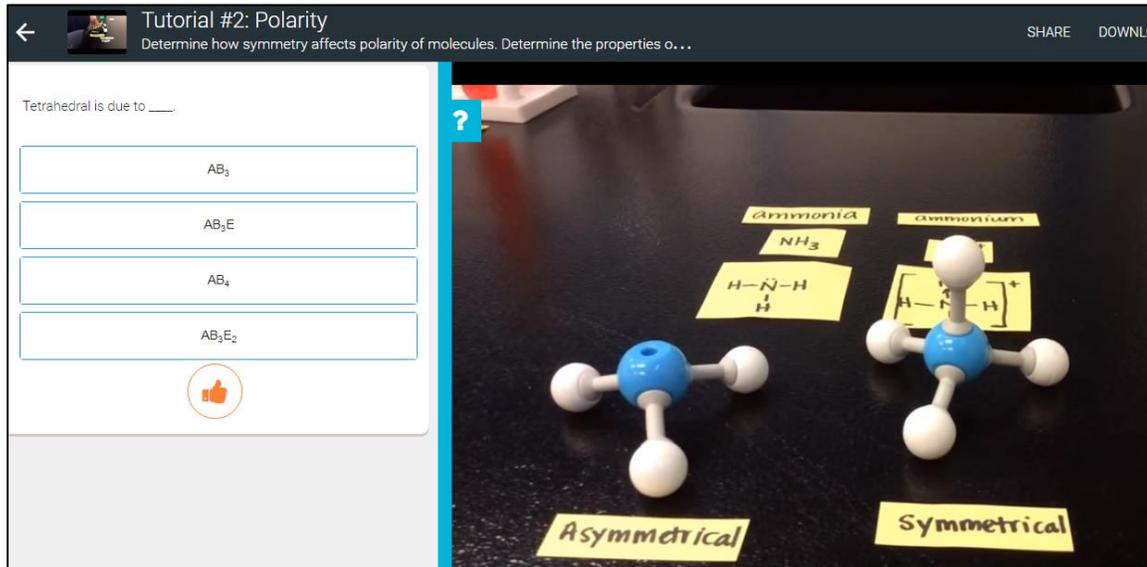


Figure 1. Mid-tutorial quiz example.

The tutorials used during the first and second treatments were filmed after school in my classroom using an iPad. To film, I used an assortment of tactile materials such as molecular models and small, hand-written signs to illustrate the concepts and skills that made up each unit (See Figure 1). All written work was hand-written, live, in order to minimize any undue distractions. Besides the inclusion of my hands, I chose not to appear in the films as another way to minimize distractions and increase focus on the topic at hand. Each video was uploaded to YouTube and then posted on EduCanon, a website that allows teachers the ability to upload videos and add optional questions within the framework of their videos. Once a student signs up for a free account on EduCanon, his or her viewing data and any score data stemming from video questions is available to the teacher. This process mimicked the method used by Copley (2007) in order to access video usage. Copley used simple software attached to podcast videos on a Blackboard site in order to assess usage. The quantitative data that EduCanon provided

was extremely useful in correlating video usage and quiz data with formal assessment scores, however it was equally as beneficial in correlating usage with anxiety and confidence levels.

All fifteen of my students signed up for a free EduCanon account and then subscribed to my personal EduCanon site, allowing me to record overall student usage and quiz scores throughout my implementation. The added benefit of this particular website is that it prevents a student from fast-forwarding the video content and only notifies a teacher when the complete video has been watched. Due to these features, I was able to conclude with certainty that students watched the videos in their entirety without skipping any content.

During the first treatment, students were given accompanying worksheets to complete while watching the tutorial videos. Hard copies were given to all students with soft copies remaining available on my teacher webpage to ensure all students had the correct materials necessary for a successful treatment. In the tutorial videos, I explained how to solve various problems, and sometimes the exact problems that appeared on their worksheets. For instance, since the first treatment focused on the topic of covalent compounds and molecular bonding, one of the tutorials explained how to determine the molecular shape from the structural formula of a covalent compound.

For the second treatment, I added an average of five questions to each tutorial. The questions were interspersed throughout each video and students could see ahead of time when a quiz question would pop up. The questions were all multiple choice in nature and each question immediately followed an example problem or explained skillset

that pertained to a specific topic in polarity. There was no time limit to answering the quiz questions and the video automatically paused until the answer was selected.

Immediate feedback was given to the students (See Figure 2). The correct answer was provided and a final score was given at the conclusion of the tutorial.

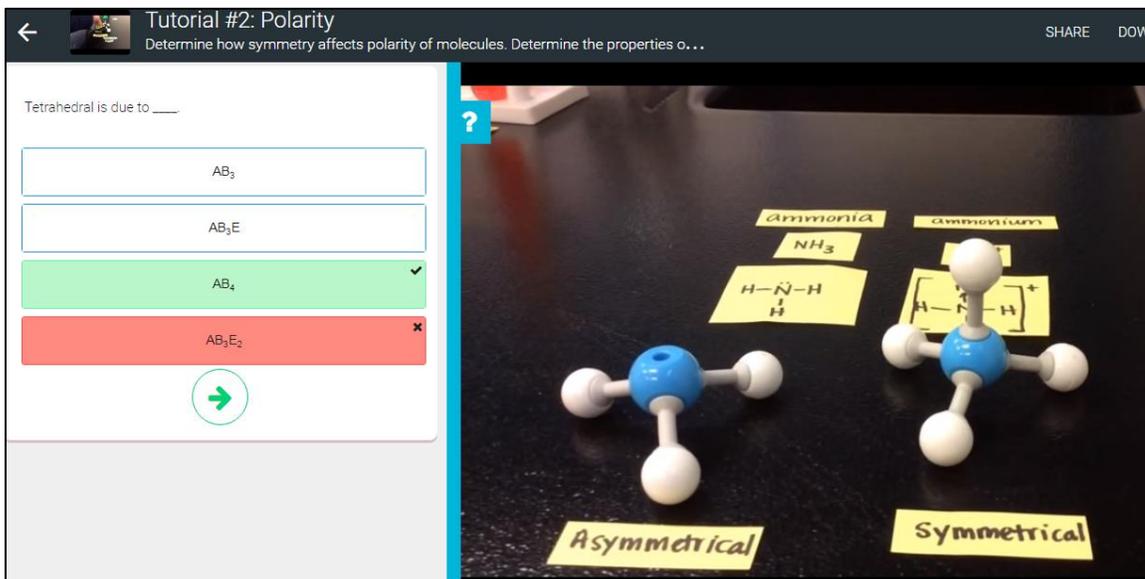


Figure 2. Mid-tutorial quiz feedback.

In addition to the formal assessments in the classroom, the mid-tutorial quiz scores from the second treatment were incorporated as actual quiz grades in the students' grade reports. Students were reminded that the set of questions in each tutorial was worth a quiz grade. This treatment of mid-tutorial quizzes is similar to the 2013 Szpunar, Khan, and Schacter study of mid-lecture memory assessments. Since the majority of my students have ADHD, the primary focus of the second treatment was to determine whether mid-memory assessments create a more focused setting and therefore a more fruitful learning environment for my student population. The thought was that my students would be more inclined to listen to the tutorials if they knew that a quiz question was about to pop up on the screen.

Discovering how knowledge might be improved as a direct result of my treatments is noteworthy; however, the aim of my project also extended beyond knowledge and dealt with measuring confidence and anxiety levels in my primarily ADHD population of students. As a result, my treatments also included conducting surveys and interviews to measure the levels of confidence and anxiety. I collected this data on three separate occasions: at the conclusion of the comparison week, at the conclusion of the first treatment, and at the conclusion of the second treatment. This is similar to the Copley (2007) study in which students were surveyed before, during, and after the inclusion of video lectures in order to determine whether student confidence and anxiety levels were affected.

It was my hope that students improve their comprehension of chemistry concepts and also become more confident learners. This action research project afforded me the opportunity to witness the effectiveness of some very promising treatments, but also to improve my own pedagogy in the process.

#### Data Collection Methods

My action research project was implemented from January through March of 2016. The Data Triangulation Matrix in Table 1 displays the various collection tools implemented for this project.

To ascertain whether the online tutorials increased student comprehension, I collected three data sources: formative assessments, rubrics scores, and a Likert Agreement Survey. I compiled the data from formative assessments into an Excel spreadsheet and analyzed the statistics surrounding the quiz and test scores over the

course of the three units of project implementation: comparison, first treatment, and second treatment. I used a skills rubric scaled from 1 (*Poor*) to 4 (*Excellent*) for each of the three units to measure the accuracy of the students' skills in each unit. The pre-treatment unit rubric contained an ionic bonding skill set (Appendix A). The first treatment unit rubric contained a covalent bonding skill set (Appendix B). The second treatment unit rubric contained a polarity skill set (Appendix C). The rubric scores were collected at the end of each unit and determined from the formative unit tests in order to give a clear picture of comprehension after maximum review and studying. A 5-point Likert scale was given to my students at the conclusion of each unit that asked whether they felt that their comprehension level had increased as a direct result of the tutorials (Appendix D). The Likert scale ratings ranged from 1 (*Strongly Agree*) to 5 (*Strongly Disagree*).

In order to measure whether the addition of the mid-tutorial quizzes further increased student comprehension, the same three data sources were used: formative assessments, rubrics scores, and a Likert Agreement Survey. The data sources remained consistent with the exception of some of the Likert Agreement Survey questions that were edited to account for the addition of the mid-tutorial quizzes (Appendix E).

To measure anxiety and confidence levels I collected three data sources: a Likert Agreement Survey, a Confidence Survey, and a Focus Group Interview. The Likert scale captured anxiety and confidence levels, but a more in-depth Confidence Survey was also given to students. The 5-point Confidence Survey rated from 1 (*Not Confident at All*) to 5 (*Extremely Confident*) (Appendix F). A Focus Group Interview (Tutorials) was also

given to students at the conclusion of the unit and asked such questions as, “Did watching the tutorials increase your confidence level in this class?”, and “Did watching the tutorials decrease your anxiety in taking quizzes and the unit test?” (Appendix G). A similar Focus Group Interview (Mid-Tutorial Assessments) was also given to account for the addition of quizzes (Appendix H).

To measure the overall effectiveness of the tutorials, I collected three data sources: the Focus Group Interview, a Focus Group Discussion, and my own observations. I gave a Focus Group Interview at the conclusion of each of the three units and had a Focus Group Discussion with both classes. The Focus Group Interview asked such questions as “Which tutorial did you think was most helpful and why?”, and “Did you think the tutorials were too long, too short, or just the right length?” Due to the small class sizes that Commonwealth Academy affords, I had the ability to ask each student for their feedback using a group discussion format. Throughout implementation, I made observations on the effectiveness of the tutorials. This gave me the opportunity to collect additional feedback not measured in the other formal collection tools.

All data collected during this capstone project fell within the exemption provided by Montana State University’s Institutional Review Board.

Table 1  
*Data Triangulation Matrix*

<i>Focus Question:</i> What is the impact of supplemental online tutorials on the comprehension level of chemistry concepts on students diagnosed with ADHD?			
<i>Sub-Questions</i>	Data Source 1	Data Source 2	Data Source 3
<i>Sub-Question 1:</i> Does the use of online tutorials increase student comprehension?	Formative Assessments: Assessments and Quizzes	Rubric Scores	Likert Agreement Survey
<i>Sub-Question 2:</i> Does the addition of mid-memory assessments into the online tutorials further increase student comprehension?	Formative Assessments: Assessments and Quizzes	Rubric Scores	Likert Agreement Survey
<i>Sub-Question 3:</i> Does the use of online tutorials decrease anxiety levels and improve confidence levels regarding chemical concepts?	Confidence Survey	Likert Agreement Survey	Focus Group Interviews
<i>Sub-Question 4:</i> How are supplemental videos effective in increasing overall achievement in chemistry?	Focus Group Interviews	Focus Group Discussion	Observations

## DATA AND ANALYSIS

The process of enacting treatments and collecting data for this project lasted approximately three months, from January to March 2016. During that time, the metropolitan area suffered many snowstorms that led to a considerable amount of cancelled classes. Despite the cancellations and interrupted treatments, the data analysis reflected encouraging results. The treatments proved extremely successful for my students.

*Impact of tutorials on student comprehension*

In my first research question, I explored the impact of the online tutorials on the comprehension levels of my students. I used data from the students' formative assessments, rubric scores and surveys to investigate this impact. I found that my treatment had a positive impact on my students. The assessment grades in Table 2 show a tremendous comprehension increase with the addition of the tutorials into my lessons. The average formal test score was a 68.8% prior to treatment and an 82.4% after treatment, an increase of 13.6 percentage points ( $N=15$ ). Quiz averages also increased at a lesser degree by approximately 4.5 percentage points, from an 82.3% to an 87.0%. The standard deviation values indicate a closer distribution in assessment scores after the addition of the tutorials. The chart in Figure 3 illustrates the positive impact on comprehension.

Table 2  
*Averages of Student Assessments (N=15)*

Treatment	Grade Percentage	Standard Deviation
No Treatment		
Quiz Average	82.3	19.5
Test Average	68.8	21.9
Grade Average	71.5	19.6
First Treatment		
Quiz Average	87.0	16.4
Test Average	82.4	13.9
Grade Average	83.3	13.0
Second Treatment		
Tutorial Quiz Average	78.7	22.7
Quiz Average	90.7	12.5
Test Average	80.5	16.2
Grade Average	80.9	14.1

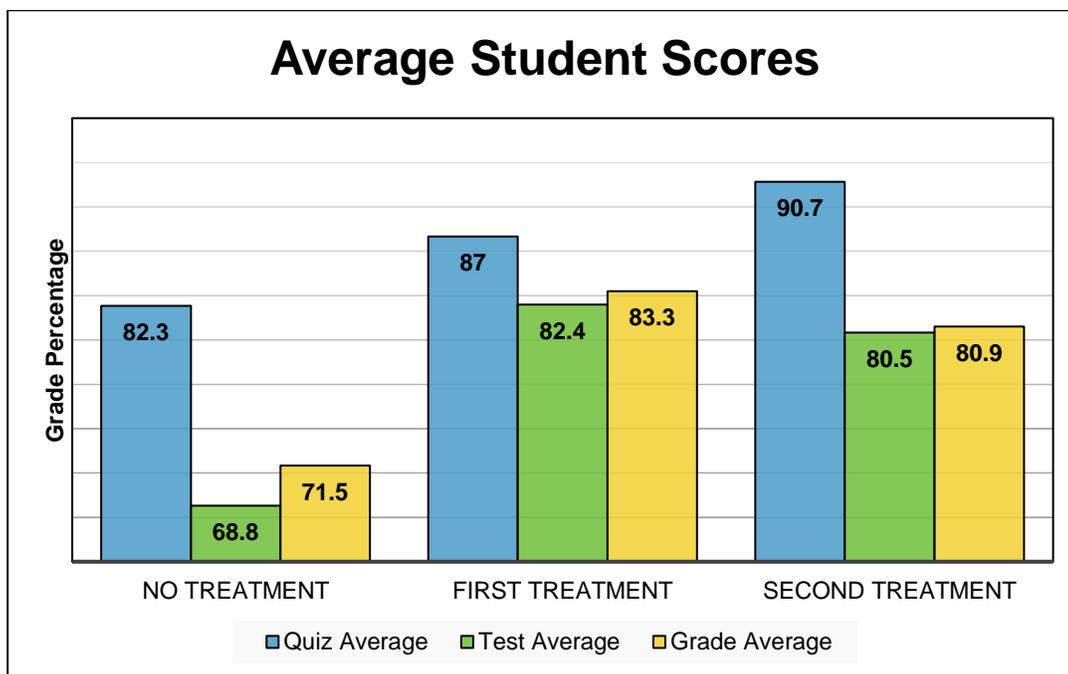


Figure 3. Average student scores of pre-treatment, first treatment and second treatment, (N=15).

Examination of the rubric scores demonstrated a greater frequency of *Excellent* in the rubrics for skills understood after the implementation of tutorials. For example, the rubric skill “ability to determine the electron dot diagram for an element” overlapped in the pre-treatment and first treatment units (Tables 3 and 4). Analyzing the rubric scores from these units, there was a 67% increase in *Excellent* post-treatment (comparing 33% in pre-treatment to 100% in the first treatment). Repetition of this concept in the classroom may have played a role in the classes’ skill increase but the large margin of percentage increase demonstrates that the tutorials assisted students tremendously.

Table 3  
*Skills Rubrics for Pre-Treatments (N=15)*

Skills Rubric: Ionic Bonding				
	1=Poor	2=Fair	3=Good	4=Excellent
Ability to determine Group Number of an atom	0%	13%	13%	73%
Ability to determine Electron Dot Diagram for an atom	7%	33%	27%	33%
Ability to determine ionic charge for an ion	0%	27%	7%	67%
Ability to determine ionic compound formula	27%	13%	0%	60%
Ability to draw an ionic compound	33%	13%	27%	13%
Ability to recall physical properties of ionic compounds	13%	7%	7%	67%

Table 4  
*Skills Rubric for Tutorial Treatment (N=15)*

Skills Rubric: Covalent Bonding				
	1=Poor	2=Fair	3=Good	4=Excellent
Ability to determine Group Number of an atom	0%	0%	0%	100%
Ability to determine Electron Dot Diagram for an atom	0%	0%	0%	100%
Ability to covalently bond two atoms	7%	0%	0%	93%
Ability to covalently bond multiple atoms	7%	0%	20%	73%
Ability to determine the molecular shape of a molecular compound	7%	0%	7%	87%
Ability to understand that the VSEPR Theory predicts the shapes of molecules	0%	20%	0%	80%

Table 5  
*Skills Rubric for Tutorial and Quiz Treatment (N=15)*

Skills Rubric: Polarity				
	1=Poor	2=Fair	3=Good	4=Excellent
Ability to determine electronegativity difference between two atoms	7%	0%	0%	93%
Ability to determine the AB formula	7%	0%	13%	80%
Ability to correctly determine shape name	0%	0%	7%	93%
Ability to draw the molecular shape of a molecular compound using stereochemistry	0%	13%	7%	80%
Ability to add dipoles using electronegativity values	20%	7%	13%	60%
Ability to determine whether a molecule is polar or nonpolar	0%	7%	27%	67%

Approximately 66% of the students surveyed listed that the tutorials improved their comprehension (53% *Agree* and 13% *Strongly Agree*) (Table 6). Students revealed on the Focus Group Interviews that they felt the tutorials were very effective in helping them learn concepts. One student said that the tutorials “helped reinforce knowledge learned in class.”

Table 6  
*Likert Agreement Survey Displaying Comprehension, Confidence and Anxiety Levels, First Treatment (N=15)*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Tutorials increased my understanding of this unit's material.	0%	13%	20%	53%	13%
Tutorials increased my confidence level in this unit's material.	0%	33%	13%	40%	13%
Tutorials decreased my anxiety levels in preparing for this unit's test.	0%	20%	40%	40%	0%
Tutorials were helpful, overall.	0%	7%	0%	53%	40%

*Impact of mid-memory assessments on student comprehension*

In my second research question, I explored the impact of adding quizzes into the tutorials in order to further increase student comprehension. I gathered data from the students' formative assessments, rubric scores and surveys to investigate this impact. I found that the average assessment scores remained rather constant compared to the scores of the first treatment. Table 2 indicates that the in-class quiz scores increased minimally after the second treatment. The average in-class quiz score was an 87.0% prior to the second treatment and a 90.7% after the second treatment: an increase of 3.7 percentage points. The average test score dropped by approximately 1.5%.

The mid-tutorial quiz data had mixed results. The average score was 78.7% which was 3.6 percentage points lower than the pre-treatment in-class quiz scores. Student feedback on the addition of quizzes was also mixed. One student remarked that he "did not think of the quizzes as real quizzes since they were not taken in the

classroom.” Another student felt the quizzes assisted with comprehension when he said, “I paid more attention and answered questions correctly.”

The rubric scores indicated a positive shift in comprehension compared to the pre-treatment results, but a slightly negative shift when compared to the first treatment results (Table 5).

#### *Impact of tutorials on anxiety and confidence levels*

In my third research question, I explored the impact of tutorials on anxiety and confidence levels in my students. I used data from surveys and Focus Group Interviews. I found that my treatment had a positive impact on my students. Students generally felt less anxious as a direct result of these videos and quizzes. One student remarked, “[Tutorials] decreased my anxiety for test-taking because I went over things more.” Another student commented, “[T]he tutorials decreased my anxiety because I knew the stuff.” A third student revealed that his confidence level in the class increased since he “knew the basics but then [he] learned faster and more.”

Figure 4 shows the Average Confidence Levels of Pre-Treatment, First Treatment and Second Treatment. Both the First and Second Treatments show an increase in confidence level compared to the Pre-Treatment.

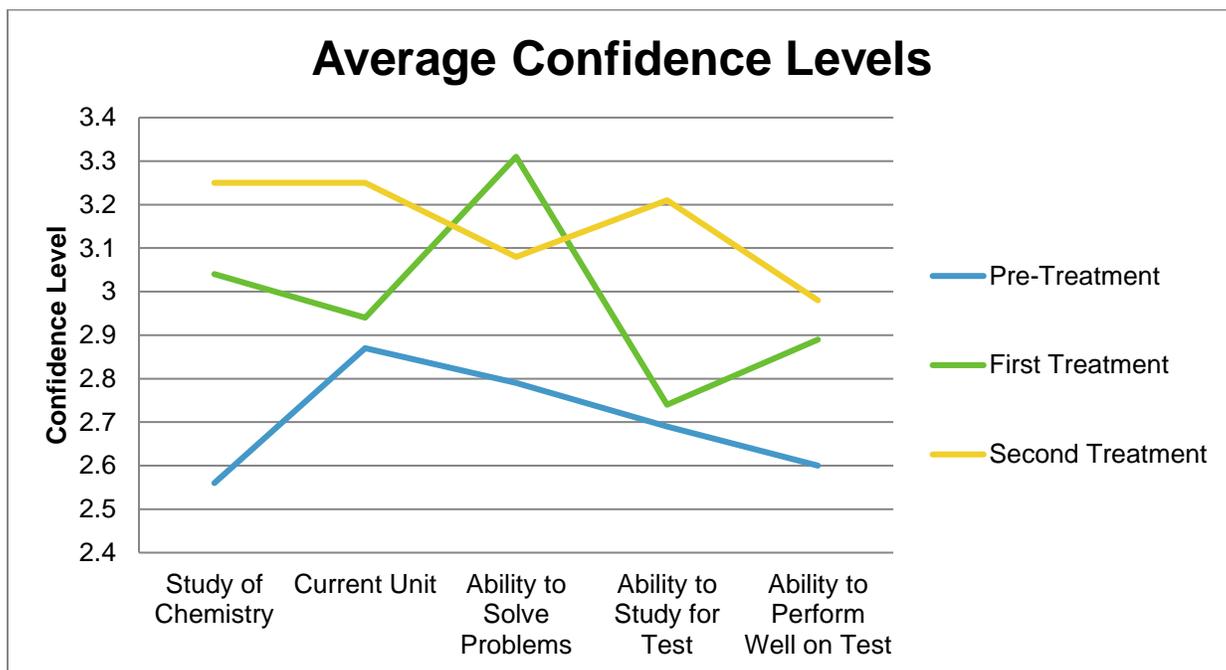


Figure 4. Average confidence levels of pre-treatment, first treatment and second treatment (5 = extremely confident, 1 = not confident at all), (N=15).

Table 7

Confidence Survey Pre-Treatment (N=15)

Comparison Week Questions	Not Confident	Slightly Confident	Confident	Very Confident	Extremely Confident
1. How confident do you feel in the study of chemistry?	29%	14%	36%	14%	7%
2. How confident do you feel in this particular chemistry unit?	14%	21%	29%	36%	0%
3. How confident do you feel in your ability to correctly solve this unit's chemistry problems?	7%	43%	14%	36%	0%
4. How confident do you feel in your ability to study for this unit's test?	21%	21%	29%	21%	7%
5. How confident do you feel in your ability to perform well on this unit's test?	29%	14%	29%	29%	0%

Tables 7, 8, and 9 display the confidence and anxiety levels of students throughout the implementation of the project. Confidence levels increased and anxiety levels decreased due to treatments. The Confidence Survey for the Pre-Treatment unit showed that only 17% students felt “very confident” in the answer to the question, “How confident do you feel in the study of chemistry?” (Table 7). The Confidence Surveys for the First and Second Treatment units showed that 27% and 42% of students felt “very confident” in the answer to the same question, respectively (Tables 8-9).

Table 8  
*Confidence Survey First Treatment (N=15)*

Treatment #1 Questions	Not Confident	Slightly Confident	Confident	Very Confident	Extremely Confident
1. How confident do you feel in the study of chemistry?	0%	40%	27%	27%	7%
2. How confident do you feel in this particular chemistry unit?	13%	27%	13%	47%	0%
3. How confident do you feel in your ability to correctly solve this unit's chemistry problems?	13%	7%	27%	47%	7%
4. How confident do you feel in your ability to study for this unit's test?	20%	13%	47%	13%	7%
5. How confident do you feel in your ability to perform well on this unit's test?	27%	7%	27%	33%	7%

Table 9  
*Confidence Survey Second Treatment (N=15)*

Treatment #2 Questions	Not Confident	Slightly Confident	Confident	Very Confident	Extremely Confident
1. How confident do you feel in the study of chemistry?	0%	33%	17%	42%	8%
2. How confident do you feel in this particular chemistry unit?	8%	17%	25%	42%	8%
3. How confident do you feel in your ability to correctly solve this unit's chemistry problems?	8%	17%	42%	25%	8%
4. How confident do you feel in your ability to study for this unit's test?	0%	25%	33%	33%	8%
5. How confident do you feel in your ability to perform well on this unit's test?	17%	17%	25%	33%	8%

This showed a positive shift of 25% in more students feeling “very confident” in the course. These positive impacts were also observed in the Likert Agreement Surveys of Tables 6 and 10.

Table 10  
*Likert Agreement Survey Displaying Comprehension, Confidence and Anxiety Levels,  
 Second Treatment (N=15)*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Video quizzes increased my understanding of this unit's material.	0%	25%	17%	33%	25%
Video quizzes increased my confidence level in this unit's material.	0%	25%	17%	42%	17%
Video quizzes decreased my anxiety levels in preparing for this unit's test.	17%	17%	25%	25%	17%

*Effectiveness of tutorials in increasing overall achievement in chemistry*

In my fourth research question, I explored how effective the tutorials were in increasing overall achievement in chemistry. I used data from Focus Group Interviews, observations, and Focus Group Discussions. I discovered that supplemental video tutorials were effective for my students when the average length of the videos was between five and eight minutes.

During treatment, the tutorials varied in length from five to fifteen minutes. Some topics required longer explanations and, therefore, additional filming time. For instance, multistep problems such as drawing molecular shapes took more time to explain than simpler problems like naming ionic compounds. The students were split on whether this range of length was helpful for their learning. Eight out of fifteen students felt that the tutorials were of the right length whereas the remaining seven indicated that they lost focus and would like videos to be shorter. One student said, "I thought they were good when they were about 8 minutes long." While some students commented that the longer

tutorial lengths made them lose focus, others commented that the longer videos allowed for more instruction and helped to dispel misunderstandings. One student said, “The length of the tutorials was just right because sometimes I needed more information to really understand it at all.”

Many ADHD students need routine and can lose focus when faced with the unfamiliar. Many students felt that the tutorials were effective due to familiarity. One student commented, “I liked the videos because it was my teacher speaking. It was almost like muscle memory. The same way you taught it in class was the way it was taught in the video. It was very familiar and reminded me of the material we learned.” Another student said, “I liked the videos. I thought that it helped to have someone speaking. I liked how [the video] wasn’t scripted. I liked the way you explained everything and showed us how to do problems step-by-step.”

All students declared that they watched the videos in places of concentration. Students remarked that the tutorials were a great advantage to learning since they could watch the tutorials when they were least distracted.

Other teachers without a science degree were better able to assist my students during study halls. Some teachers watched the videos along with the student and were better able to assist students with their chemistry homework.

Unintended student feedback was oftentimes the most helpful data. For instance, after I had finished my treatment and data collection, I stopped making tutorials. The tutorials had become a routine for the students and many of them inquired about the sudden dearth of videos. I noticed that most students inquired on days when the course

material was especially challenging or wrought with mathematical calculations. In order to clarify whether the students were simply remarking on the lack of the videos or actually asking me to post new videos, I decided to casually survey both sections. When asked whether they would like tutorials for the current unit, every single student raised their hand. This was telling for a couple of reasons. Some students had not been as forthcoming with their surveyed opinions regarding the benefits of videos during official treatment. In addition, some outliers had chosen not to watch some of the tutorials. It can be surmised that the students were most able to recognize the value of tutorials once they no longer existed.

#### INTERPRETATION AND CONCLUSION

The results of this capstone project indicate that the addition of five to eight minute long supplemental tutorials into a chemistry curriculum effectively increases overall comprehension in ADHD students. Furthermore, the addition of the tutorials had a measurable effect on students decreasing their anxiety levels and increasing their confidence levels in the class. Students appeared more empowered to tackle problems and more involved during class time. The tutorials appeared to narrow a comprehension gap among the highest and lowest achieving students.

The degree of increased comprehension mirrors the successes acknowledged by He, Swenson, and Lents in their 2012 study of supplemental online videos. Their second-year undergraduate chemistry students also improved their comprehension regarding chemistry topics when supplied with online tutorial videos.

The implementation of mid-tutorial quizzes was met with mixed results and was not particularly effective in increasing student comprehension when compared to the first treatment. The motive behind the quizzes was to assist ADHD students in maintaining focus while watching the tutorials. The 2013 study completed by Szpunar, Khan, and Schacter demonstrated that their mid-memory tests were found to lessen anxiety and help their students perform better on tests. Since my students' grades did not readily increase after the introduction of the mid-tutorial quizzes, it can be surmised that the content within the tutorials was effectively digested and processed by my students without the need for additional refocusing measures (within a span of 5 – 8 minutes).

While the proficiency of skill-based problems increased on assessments, it is interesting to note that the knowledge of vocabulary did not increase accordingly. This is not surprising since the content in the tutorials focused primarily on reviewing skills and solving problems. This demonstrates yet again the direct correlation between the material covered in the tutorials and the performance of students on assessments. In future interventions, I would like to employ more vocabulary-based material into my tutorials. In addition, laboratory skills are crucial to further lab sciences, and I would also like to include tutorials that focus on lab design and proper safety adherence in future implementation.

#### VALUE

This project was eye opening for me as a chemistry teacher. I found it extremely fascinating that the tutorials made such a tremendous impact on my ADHD students' comprehension levels. It was immediately evident how focusing challenges and anxieties

truly interfere with learning. It was encouraging to see underperforming students achieve higher marks and develop increased confidence levels in their study of chemistry.

From a professional standpoint, this project improved my pedagogy immensely. I created multiple tutorial lessons that will benefit my future students for years to come. I discovered that the timing of videos was extremely important in maintaining a good focusing balance for my ADHD students.

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APPENDICES

APPENDIX A  
SKILLS RUBRICS (PRE-TREATMENT)

Skills Rubric: Ionic Bonding				
	1=Poor	2=Fair	3=Good	4=Excellent
Ability to determine Group Number of an atom				
Ability to determine Electron Dot Diagram for an atom				
Ability to determine ionic charge for an ion				
Ability to determine ionic compound formula				
Ability to draw an ionic compound				
Ability to recall physical properties of ionic compounds				

APPENDIX B  
SKILLS RUBRICS (FIRST TREATMENT)

Skills Rubric: Covalent Bonding				
	1=Poor	2=Fair	3=Good	4=Excellent
Ability to determine Group Number of an atom				
Ability to determine Electron Dot Diagram for an atom				
Ability to covalently bond two atoms				
Ability to covalently bond multiple atoms				
Ability to determine the molecular shape of a molecular compound				
Ability to understand that the VSEPR Theory predicts the shapes of molecules				

APPENDIX C  
SKILLS RUBRICS (SECOND TREATMENT)

Skills Rubric: Polarity				
	1=Poor	2=Fair	3=Good	4=Excellent
Ability to determine electronegativity difference between two atoms				
Ability to determine the AB formula				
Ability to correctly determine shape name				
Ability to draw the molecular shape of a molecular compound using stereochemistry				
Ability to add dipoles using electronegativity values				
Ability to determine whether a molecule is polar or nonpolar				

APPENDIX D

LIKERT AGREEMENT SCALE – TUTORIALS

Name \_\_\_\_\_

Likert Agreement Survey (Tutorials)

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

1. The video tutorials increased my understanding of this unit's material.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
2. The video tutorials increased my confidence level in this unit's material.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
3. The video tutorials decreased my anxiety levels in preparing for this unit's test (I felt less anxiety.)
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
4. The video tutorials were helpful, overall.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree

APPENDIX E

LIKERT AGREEMENT SCALE – MID-TUTORIAL ASSESSMENTS

Name \_\_\_\_\_

Likert Agreement Survey (Mid-Tutorial Quizzes)

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

1. The video tutorials increased my understanding of this unit's material.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
2. The video tutorials increased my confidence level in this unit's material.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
3. The video tutorials decreased my anxiety levels in preparing for this unit's test.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
4. The video tutorials were helpful, overall.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
5. The video quizzes increased my understanding of this unit's material.
  - 1) Strongly Agree
  - 2) Agree
  - 3) Neither agree nor disagree
  - 4) Disagree
  - 5) Strongly Disagree
  
6. The video quizzes increased my confidence level in this unit's material.
  - 1) Strongly Agree
  - 2) Agree

- 3) Neither agree nor disagree
- 4) Disagree
- 5) Strongly Disagree

7. The video quizzes decreased my anxiety levels in preparing for this unit's test.

- 1) Strongly Agree
- 2) Agree
- 3) Neither agree nor disagree
- 4) Disagree
- 5) Strongly Disagree

APPENDIX F  
CONFIDENCE SURVEY

Name \_\_\_\_\_

Confidence Survey

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

8. How confident do you feel in the study of chemistry?
  - 1) Not confident at all
  - 2) Slightly confident
  - 3) Confident
  - 4) Very confident
  - 5) Extremely confident
  
9. How confident do you feel in this particular chemistry unit?
  - 1) Not confident at all
  - 2) Slightly confident
  - 3) Confident
  - 4) Very confident
  - 5) Extremely confident
  
10. How confident do you feel in your ability to correctly solve this unit's chemistry problems?
  - 1) Not confident at all
  - 2) Slightly confident
  - 3) Confident
  - 4) Very confident
  - 5) Extremely confident
  
11. How confident do you feel in your ability to study for this unit's test?
  - 1) Not confident at all
  - 2) Slightly confident
  - 3) Confident
  - 4) Very confident
  - 5) Extremely confident
  
12. How confident do you feel in your ability to perform well on this unit's test?
  - 1) Not confident at all
  - 2) Slightly confident
  - 3) Confident
  - 4) Very confident
  - 5) Extremely confident

APPENDIX G

FOCUS GROUP INTERVIEW (TUTORIALS)

Name \_\_\_\_\_

Focus Group Interview (Tutorials)

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

1. Did you watch the tutorials in a place where you could concentrate?
2. What time of day did you watch the tutorials?
3. Did you watch the tutorials at school or at home? Or both?
4. If you answered "both" for the previous question, where did you *prefer* to watch the tutorial (school or home?) and why?
5. Do you feel the tutorials helped increase your knowledge of the material in this chemistry unit?
6. Did your overall grade improve during this time? Explain.
7. Did watching the tutorials increase your confidence level in this class? If so, how?
8. Did watching the tutorials decrease your anxiety level in this class? If so, how?
9. Did watching the tutorials decrease your anxiety level in taking quizzes and the unit test? If so, how?
10. Did watching the tutorials increase your confidence level in science, in general? If so, how?
11. Which tutorial did you think was most helpful and why?
12. What skill did you most improve on by using the tutorials?
13. Did you think that the tutorials were too long, too short, or just the right length? Explain.
14. Would you like to see these tutorials in all future units of chemistry?
15. Do you feel you are better prepared for future chemistry units as a direct result of these tutorial videos?
16. Do you have any other comments regarding the tutorials?

APPENDIX H

FOCUS GROUP INTERVIEW (TUTORIALS AND QUIZZES)

Name \_\_\_\_\_

Focus Group Interview (Tutorials and Quizzes)

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

1. Did you watch the tutorials and take the quizzes in a place where you could concentrate?
2. What time of day did you watch the tutorials and take the quizzes?
3. Did you watch the tutorials and take the quizzes at school or at home? Or both?
4. If you answered "both" for the previous question, where did you *prefer* to watch the tutorial and take the quizzes (school or home?) and why?
5. Do you feel the addition of the quizzes helped increase your knowledge of the material in this chemistry unit? Why or why not?
6. How did your grade change with the addition of the quizzes to the tutorials? Did your grade decrease, increase, or remain the same? Explain.
7. Did the addition of the quizzes increase your confidence level in this class? If so, how?
8. Did the addition of the quizzes decrease your anxiety level in this class? If so, how?
9. Did the addition of the quizzes decrease your anxiety level in taking in-class quizzes and the unit test? If so, how?
10. Did the addition of the quizzes increase your confidence level in science, in general? If so, how?
11. Which tutorial did you think was most helpful and why?
12. What skill did you most improve on by using the tutorials?
13. Did you think that the tutorials were too long, too short, or just the right length? Explain.
14. Would you like to see these tutorials in all future units of chemistry?
15. Do you feel you are better prepared for future chemistry units as a direct result of these tutorial videos?
16. Do you have any other comments regarding the tutorials?