

THE EFFECTS OF THE FLIPPED CLASSROOM ON THE ACADEMIC
ACHIEVEMENT OF CHEMISTRY STUDENTS WHEN COMPARED
TO THOSE IN THE TRADITIONAL SETTING

by

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TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND	1
2. CONCEPTUAL FRAMEWORK	2
3. METHODOLOGY	7
4. DATA AND ANALYSIS	10
5. INTERPRETATION AND CONCLUSION	20
6. VALUE	22
REFERENCES CITED.....	24
APPENDICES	27
APPENDIX A: IRB Exemption	28
APPENDIX B: Mole Pretest.....	30
APPENDIX C: Moles Test	33
APPENDIX D: Bonding Pretest	36
APPENDIX E: Bonding/Naming Test	39
APPENDIX F: Pre-Lesson Student Survey.....	43
APPENDIX G: Post Lesson Student Survey	45
APPENDIX H: Student Interview Questions	47

LIST OF TABLES

1. Class Demographics: Ethnicity.....	7
2. Triangulation Matrix.....	9

LIST OF FIGURES

1. Box and Whisker Plots of Mole Pre-Test and Mole Test Scores	10
2. Box and Whisker Plots of the Mole Pre-Test and the Mole Test Scores Using Traditional Methods	11
3. Box and Whisker Plots of Bonding Pre-Test and Bonding/Naming	12
Test Scores	
4. Box and Whisker Plots of Bonding Pre-Test and Bonding/Naming	13
Test Scores Using Traditional Methods.	
5. Student Responses from the Pre-Lesson Student Survey and	15
Post-Lesson Student Survey	
6. Students responses from the Pre-Lesson Student Survey and	16
Post-Lesson Student Survey	
7. Students responses from the Pre-Lesson Student Survey and	17
Post-Lesson Student Survey	
8. Student Responses to Select Questions on Post-Lesson Student Survey	18
9. Student Responses to Select Questions on Post-Lesson Student Survey	20

ABSTRACT

With the increasing number of standardized tests and the resulting implications, the need for quality class time with students has become even more important. Several techniques for improving instruction have been introduced over the past few years. One such technique is the flipped classroom model. This project investigated the effectiveness of the flipped model. Over the course of two units, student watched video lessons at home and class time was used for hands-on activities, laboratories and doing activities that traditionally would be considered homework in the presence of a teacher that can answer questions. The results of this study were then compared to a class taught using traditional techniques to determine the effectiveness.

INTRODUCTION AND BACKGROUND

Walker Valley High School, located in Cleveland, Tennessee, is a school of 1653 students. The school is divided into four academies: Freshmen academy, Humanities, Medical Business Administration, and STEM (Science, Technology, Engineering, and Math). The ethnicity of the school is 92% Caucasian, and students come from a variety of economic backgrounds with only 35% considered to be disadvantaged (D. Coggin, personal communication, November 21, 2015). Chemistry is a course required by all students in Tennessee and includes an end of course exam, which not only judges the student's growth but the teacher's effect has on learning as well. The long term goal of my class is not only to prepare my students for the end of course exam, but also to teach them to be confident problem solvers.

In order to adequately prepare students for the end of course exam, and ultimately college chemistry, it is important to use class time as effectively as possible. In the traditional high school classroom, teachers will lecture most of the class period and assign some type of practice. Students are then given homework that they are expected to complete on their own. Often, students encounter questions that they are unable to complete and, therefore, are not able to continue. This frequently leads to the student becoming confused and unable to keep up with what is going on in class. As the student gets further behind, he/she becomes frustrated and gives up.

The added stress of the end of course exam has left me with the tough decision of what material to leave out in order to cover all of the required information. Unfortunately, this decision has led to the omission of hands-on or laboratory experiences. These types of lessons are valuable to all students, but especially the

kinesthetic learners. In-class activities allow students who are unsure about the content to become active participants in their education and, therefore, more confident learners.

The need for additional class time for student interaction with the teacher as well as hands-on activities has left many educators, including myself, looking for an alternative way of conducting class. One such method is the flipped classroom. In a flipped classroom, students are exposed to new material at home using videos or reading assignments in lieu of classroom lectures. This leaves class time for conducting laboratories, working on problems with the teacher present, and completing hands-on activities. This idea led to the creation of my focus question: *What was the effect of the flipped classroom on the academic achievement of chemistry students when compared to those in the traditional classroom setting?* The following sub question was also addressed: *Did the use of the flipped classroom have a positive effect on student's attitudes toward learning chemistry?*

CONCEPTIONAL FRAMEWORK

The traditional classroom is one in which the teacher is the center of the learning process and, in effect, causes learning to take place (Novak, 1998). This model of education was designed during the Industrial Revolution. Students sit in rows, much like an assembly line, and are expected to learn and recall information provided by the instructor (Bergman & Sams, 2012). Lectures give students access to new knowledge but do not allow them the opportunity to learn at different paces. What might be difficult for one student may be simple for another (Goodwin & Miller, 2013). According to Bergman and Sams (2012), this is most likely due to the fact that students, “lack

background knowledge, are uninterested in the material, or have simply become disenchanted with the present educational model” (para. 3). Each student comes to the classroom with different background knowledge, which makes it nearly impossible to personalize each student’s education. Therefore, traditional teachers tend to introduce large quantities of knowledge and hope to reach as many students as possible. The difficulty is that there is no guarantee the student has learned anything in class or at home (Silverthorn, 2006). In order to reach each student, it is necessary to provide a personalized education plan. Personalization is overwhelming and almost impossible in the traditional classroom due to logistics (Bergman & Sams, 2012).

The flipped classroom, which takes an opposite approach to learning, is defined as a reversal of traditional teaching where students gain first exposure to new materials outside of class. Exposure to materials is usually done via reading or lecture videos, and class time is used to do the harder work of assimilating that knowledge through strategies such as problem-solving, discussion, or debates (Brame, 2013). “Instead of the lecture taking place inside the classroom, students gain exposure to new concepts outside of the traditional classroom” (Brame, 2013, para. 3). Students are usually asked to watch short videos as homework instead of completing general textbook assignments (Arnaud, 2013). The purpose of this is to allow class time to be used for processing the new information. Videos are not the only method of first exposure. Teachers may also use “textbook readings, web quests, PowerPoint presentations with voice over and printable slides,” which gives students with different learning styles a variety of ways to learn (Brame, 2013, para. 8). The flipped method allows students to choose how they

want to acquire information which, in turn, creates a personalized education plan (Silverthorn, 2006).

Like every teaching method, the flipped classroom has both pros and cons. Flipping the classroom allows students to use classroom time for problem based active learning (Bechman, Thorn, & Zhao, 2014). Lectures and other low level tasks become homework, and classrooms become laboratories or studios (Gerstein, 2011). Homework becomes more meaningful as students are able to pace themselves through lectures. Through the use of technology, students are able to view the lecture as well as review difficult topics as many times as necessary, thus making the student an active participant in his/her own education (Mangan, 2013). By empowering the students, teachers are able to maximize the time spent with students in the classroom when students need them most, such as when they are stuck on a difficult problem and need guidance. In the traditional classroom, problems often arise at home with no guidance available (Bergmann & Sams, 2014). Flipping the classroom allows students to be more independent, less stressed learners because the teacher is present during the most difficult part of the lesson, usually the application of the knowledge acquired (Toppo, 2011). Students can also be used as resources to assist others in the classroom through peer learning. They are able to confidently work through complex, real-life problems with the assistance of their peers which helps cement the understanding of the concept (Arnaud, 2013). Working together as peer groups promotes teamwork and helps prepare them for a future as a global citizen (Gerstein, 2011). Another advantage of the flipped classroom is the opportunity for more one-on-one time with the instructor. This allows the student to gain immediate feedback and correct misconceptions. Research shows that teachers who are not standing

in front of the class, but circulating and talking with students, have a profound impact on student achievement (Goodwin & Miller, 2013). “It is the interaction and the meaningful learning activities that occur during the face-to-face time that is most important” (Hertz, 2012, para, 5). Students in the inverted classroom become more engaged and a more personalized education is developed. By flipping the classroom, a framework is put in place that ensures that students receive an education tailored to their needs. It enables students who are struggling with lessons time to review assignments as well as gain a deeper understanding on the lesson while others advance ahead (Bergman & Sams, 2012). Instead of pushing kids through the curriculum at the same pace, the flipped classroom allows students the opportunity to advance at their own pace.

Putting lectures online enables students to pace their own learning according to their needs. Potentially, an inverted classroom allows the teacher to place an entire year or semester’s worth of lectures online, enabling students to accelerate through the curriculum if they are ready. (Goodwin & Miller, 2013, para. 7)

Like any other new method of teaching, the flipped classroom is not without its critics. Many teachers are opposed to change. According to Mangan (2013), “It’s easier to stand up and give the same lecture you’ve been giving for 20 years than it is to rethink your course, come up with new activities and really engage your students” (p. 19). Teachers need to shift from spending time on long lectures to interacting with students and guiding them through the concepts (Frydenberg, 2012). Many instructors are reluctant to give up lecture time because they feel they have too much content and the flipped classroom will limit the amount they can cover (Silverthorn, 2006). For many educators, the problem lies in the fact that the lecture is the only form of lesson delivery they know how to use. Many educators just do not know what to do with class time that

is void of lecture (Gerstein, 2011). Another drawback of the flipped classroom, from a teacher's standpoint, is the amount of up front work that is required. Teachers must be technology savvy and must have time to create short, quality, focused videos (Frydenberg, 2012). "In order for students to be successful on their own, videos used in the flipped-classroom model must include a variety of approaches in the same way a face-to-face lesson would" (Hertz, 2012, para. 4). Student access to technology is an additional concern of many opponents of the flipped classroom. In order to be successful, students must have access to the internet and a computer. This could be impossible for students in low income districts (Acedo, 2013). Another con of the flipped classroom is that students are often resistant to change and need time to adapt to drastic overhauls in the classroom (Bergman & Sams, 2014). Students complain that the videos do not adequately prepare them to solve problems in class and leave them feeling lost (Mangan, 2013).

Due to the relative newness of the flipped classroom, evidence on its effectiveness is still forthcoming. Preliminary research seems to be positive. "In a survey of 453 teachers who flipped their classroom, 67 percent reported increased test scores, 80 percent reported increased attitudes and 99 percent said they would flip their classrooms again" (Goodwin & Miller, 2013, para. 9). One study of two sections of chemistry classes at Purdue University used the traditional lecture method in one section and the flipped method in the other. Each section was given American Chemical Society exams to normalize student performance. The flipped classroom showed a significant improvement over the traditional classroom (Arnaud, 2013). In 2014, the University of Washington conducted a study to compare traditional learning and active learning

(flipped) among 225 STEM students. The results of the study indicated that the average score improved six percent in the active learning class. Students in the traditional class were also 1.5 times more likely to fail than those in the flipped classroom (Raths, 2015). Though flipped classroom research is still on-going, “the bulk of completed research studies shows that when students learn by flipped classrooms, they perform about the same, or better on various evaluations” (Mason, Shuman & Cook, 2013). An ever changing society and technology driven students appear to make the flipped classroom a viable way to reach today’s students (Bergman & Sams, 2014).

METHODOLOGY

Research for the study of the flipped classroom was conducted in an honors chemistry class consisting of 26 students. The research methodology for this project received an exemption by Montana State University’s Institutional Review Board and compliance for working with human subjects was maintained (Appendix A). All of the students were juniors; there were 16 males and 10 females (Table 1).

Table 1
Class Demographics: Ethnicity (N=26)

Race	Latino	African American	Caucasian	Asian	Other
	3.8%	0%	88.5%	7.7%	0%

The course was taught on a 90-minute block, which traditionally is lecture, followed by some type of guided practice such as word problems or worksheets. The treatment was conducted over a period of four weeks with the flipped model used to deliver instruction. Students were assigned a short 10-12 minute YouTube video to

watch outside of class. Students were expected to come to class having watched and taken notes on the instructional video in order to be prepared for the lesson. An informal question and answer time was conducted to help with any problems or misconceptions students might have had after viewing the video. No formal lectures were given during this time; however students were free to ask questions about content covered in the video. Class time was then used to solidify concepts by students working together in small groups on hands-on assignments, working problems with the teacher present as a guide, and completing laboratory assessments.

The treatment took place over the course of two units consisting of moles and compounds. By completing more than one unit, it allowed students the opportunity to adjust to the flipped model process. Prior to the treatment, students were given the Moles Pre-Test to determine the level of knowledge on the unit (Appendix B). Information from this assessment was analyzed for median and range and displayed on a box-and-whisker plot. This helped to establish a quantitative baseline to be used as a comparison to measure growth using normalized gains. A normalized gain was needed to determine the level of growth during the treatment. This would help determine the amount of growth in not only the students that initially scored low on the pretest but the growth of the third quartile as well. These gains were analyzed using Hake's explanation of scoring which states that gains $< .2$ are considered low, medium gains are $0.3 < g < .6$ and high gains are $> .7$. The treatment was concluded with the administration of the Mole Test (Appendix C). This data was compared to the Mole Pretest to determine the amount of growth during the treatment using normalized gains. This data was displayed in a box and whisker plot. Normalized gains were then compared to data attained from a similar

class using traditional teaching methods the previous year. This allowed me to determine quantitatively the effectiveness of the treatment. The Bonding Pre-Test (Appendix D) was given and compared to the results of the Bonding/Naming Test (Appendix E). This data was analyzed using the same techniques as the mole unit.

The Pre-lesson Student Survey assessed students' attitudes toward classroom activities, class structure and chemistry in general (Appendix F). In this survey, a Likert scale ranging from 1-5, *strongly disagree(1)*, *disagree(2)*, *neutral(3)*, *agree(4)* and *strongly agree(5)* was used. The scores of the class were tallied and compared to the results of the Post Lesson Student Survey to determine the overall attitude of the group prior to treatment. The Post Lesson Student Survey was administered to determine if the attitude of the students toward the flipped classroom as well as chemistry in general had changed (Appendix G). This was similar to the Pre-lesson Student Survey administered at the beginning of the treatment and used the same scale. Data from this was tallied and displayed along with the results of the Pre-lesson Student Survey on a bar graph.

The final piece of data was collected using the Student Interview Questions (Appendix H). Six students were chosen to complete the interview. Students were chosen based on both gender and academic achievement. The data was used to answer the focus questions according to the Data Triangulation Matrix (Table 2).

Table 2
Triangulation Matrix

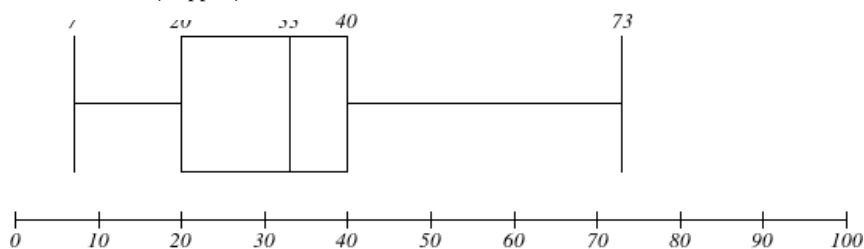
Research Question	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> Is there an increase in the academic achievement using the flipped model?	Pre and Post Tests	Student surveys	

<i>Secondary Question:</i> Did the flipped classroom have a positive effect on student attitudes toward learning chemistry?	Student Interview Surveys Student Surveys	Student Interviews	Observations
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DATA AND ANALYSIS

The results of The Mole Test using the flipped method indicated that 100 % of the students increased their test scores over the course of instruction ($N=26$). The results of the comparison of the Mole Pre-Test and The Mole Test indicated that the median grade of the class went up sixty points from 33% to 93%. The average normalized gain for the mole unit treatment was .91. The minimum grade also rose from 7% on the Mole Pre-test to 80% on the Mole Test (Figure 1).

Mole PreTest (Flipped)



Mole PostTest (flipped)

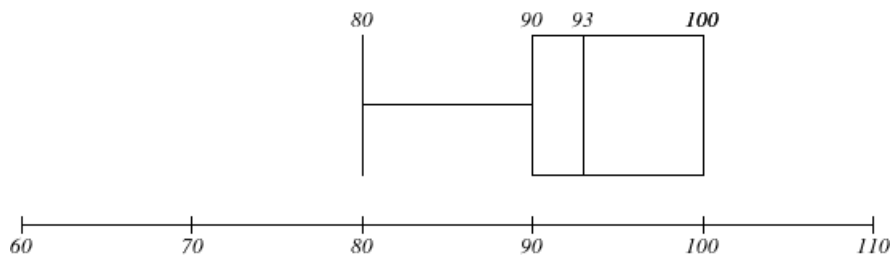


Figure 1. Box and Whisker plots of the Mole Pre-Test and the Mole Test scores, ($N=26$).

The Wilcoxon-Sign Rank Score was used to determine if the median distributions of the scores were significantly different. According to these calculations, test scores did

improve enough to be valid with a p-value of 0.00042, which was below the significance level of .05. The null hypothesis states there was no significant change in the confidence levels between the pre and posttest, and in this case, it is clearly rejected.

The results of the moles unit using the traditional teaching method indicated that 100 % of the students increased their test scores over the course instruction ($N=24$). The results of the comparison of the Mole Pre-Test and the Mole Test reveal that the median grade of the class went up 55 points from 40% to 95%. The average normalized gain for the mole unit treatment using traditional methods was 0.84. The minimum grade also rose from 10% on the pretest to 44% on the posttest (Figure2).

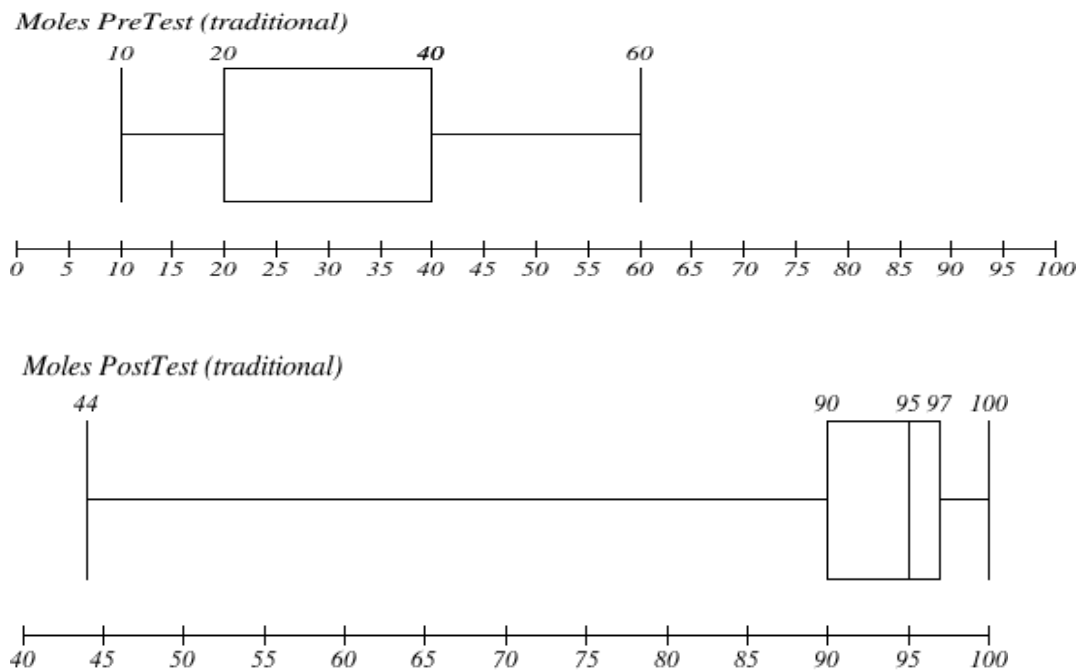


Figure 2. Box and Whisker plots of the Mole Pre-Test and the Mole Test Scores using traditional methods, ($N=24$).

The Wilcoxon-Sign Rank Score was used to determine if the median distributions of the scores were significantly different. According to these calculations, test scores did

improve enough to be valid with a p-value of $p < .001$, which was below the significance level of .05. The null hypothesis states there was no significant change in the confidence levels between the Mole Pre-Test (traditional) and The Mole Post Test (traditional) and in this case it is clearly rejected.

The Bonding/Naming Test using the flipped method, revealed that 100% of the class experienced a gain over the course of instruction ($N=26$). The average gain was 51 points per student. The median test score went up 54 points from 43% to 97%. The average normalized gain for the naming unit treatment was 0.93. The minimum score on the pretest was 34% compared to 79% on the posttest. This is a gain of 45 points (Figure 3).

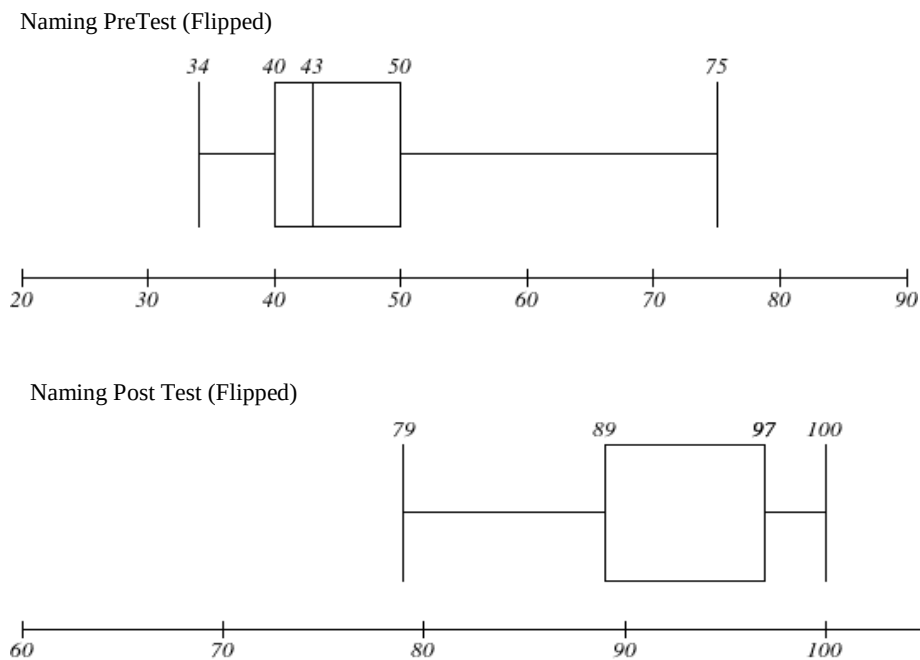


Figure 3. Box and Whisker plots of Bonding Pre-test and Bonding/naming test scores, ($N=26$).

The Wilcoxon-Sign Rank Score was used to determine if the median distributions of the scores were significantly different. According to these calculations, test scores did

improve enough to be valid with a p-value of 0.0012, which was below the significance level of .05. The null hypothesis states there was no significant change in the confidence levels between the pre and posttest, and it is rejected.

The Naming/bonding Test given after teaching using traditional methods indicates that 100% of the class experienced a gain over the course of instruction ($N=24$). The average gain was 56 points per student. The median test score went up 60 points from 38% to 98%. The average normalized gain for the naming unit treatment was 0.91. The minimum score on the Bonding Pre-Test was 20% compared to 89% on the Naming/Bonding Test. This is a gain of 69 points (Figure 4).

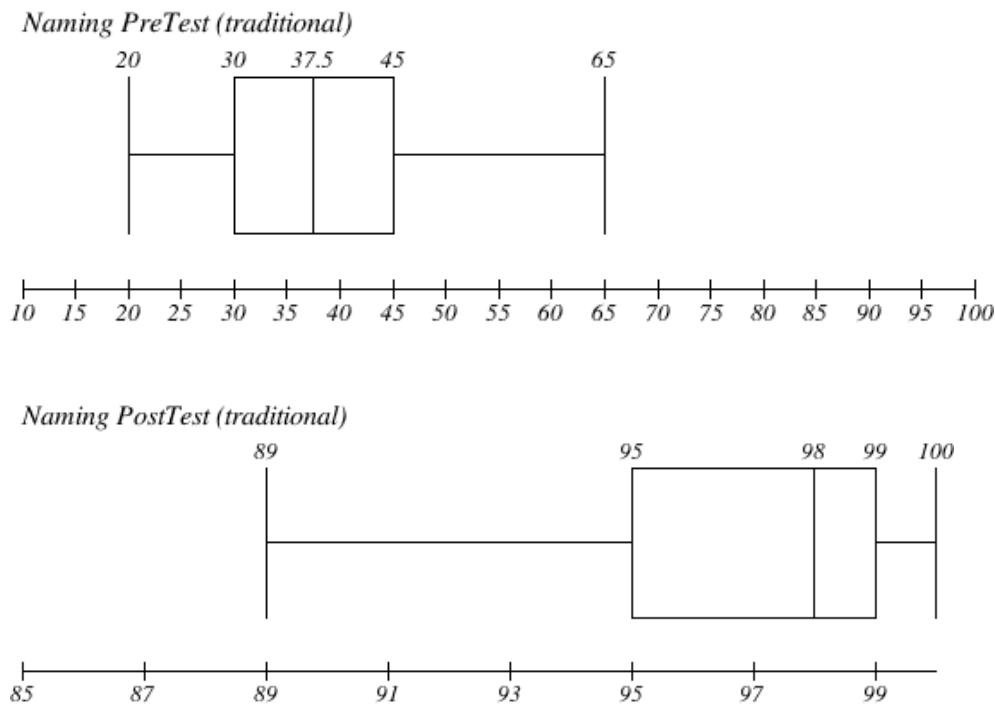


Figure 4. Box and Whisker Plots of Bonding Pre-Test and Bonding/Naming test scores using traditional methods, ($N=24$).

The Wilcoxon-Sign Rank Score was used to determine if the median distributions of the scores were significantly different. According to these calculations, test scores did

improve enough to be valid with a p-value of 0.0017, which was below the significance level of .05. The null hypothesis states there was no significant change in the confidence levels between the pre and posttest and in this case it is rejected.

The Pre Lesson Student Survey and Post Lesson Student Surveys were used to analyze the increase in student confidence during the application of the treatment. The results of the Pre Lesson Student Survey indicated that 83% of the students currently like chemistry. This increased to 85% after the treatment and revealed that the majority of students liked chemistry before the study and, therefore, there was little room for growth. An area to note is that 11% strongly disagreed that they liked chemistry on the pretest, while none felt this way after the treatment. The pretest showed that 17% strongly agreed that they liked chemistry before the treatment. This grew to 42% percent. The overall trend seems to be that the population liked chemistry more after the treatment (Figure 5).

The second statement was, *I learn best in a face to face lecture environment*. This is one area that increased over the course of the treatment. Sixty-one percent of the class indicated they were neutral or disagreed with this statement prior to treatment. This number dropped significantly on the posttest as only 17% of the class felt this way after the lesson. One student replied, “I like doing the activities, but I didn’t like watching the videos.” Prior to the treatment, only 11% of the students agreed with the statement. This number rose to 42% an increase of 31% (Figure 5).

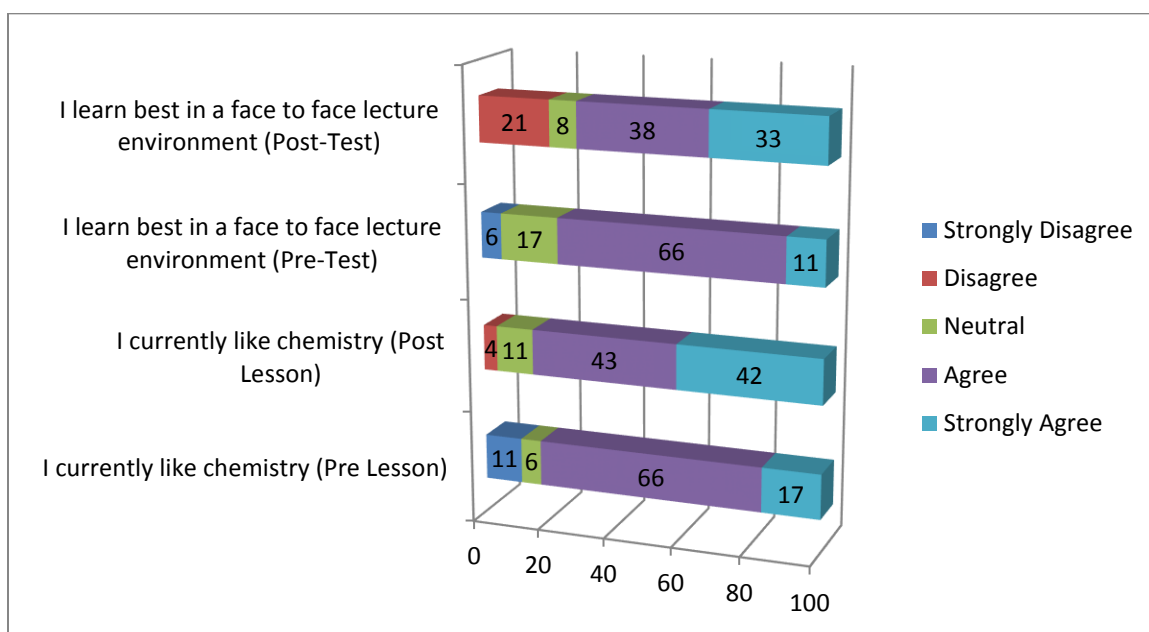


Figure 5. Students responses from the pre-lesson student survey and post-lesson student survey, (N=26).

I learn best when doing activities and group projects was the third statement, and one that experienced some large changes from the beginning of the project until the end. Prior to treatment, 44% of the class was neutral on the statement. The decrease to 29% post treatment coincided with a large jump in the number of students that agreed with the statement prior to treatment. Only 11% agreed that they learn best in group projects. This number rose to 42% after the flipped lesson. When asked her opinion on hands-on activities, one student remarked, “I really like working in groups. I really don’t like just sitting and listening,” (figure 6).

With comment number 4, *I prefer to use class time for lectures and not doing hands-on activities*, 83% of the class was neutral or disagreed with this statement. According to one of the students surveyed on the pretest, “I like doing not listening.” This number decreased slightly to 75% after the treatment. The total percentage of

students who agreed or strongly agreed with this statement was the lowest of any of the three. Only 11% agreed with this statement on the pretest; this increased to 21% on the posttest. After the treatment, the total agreement rose from 17% to 25%, (Figure 6).

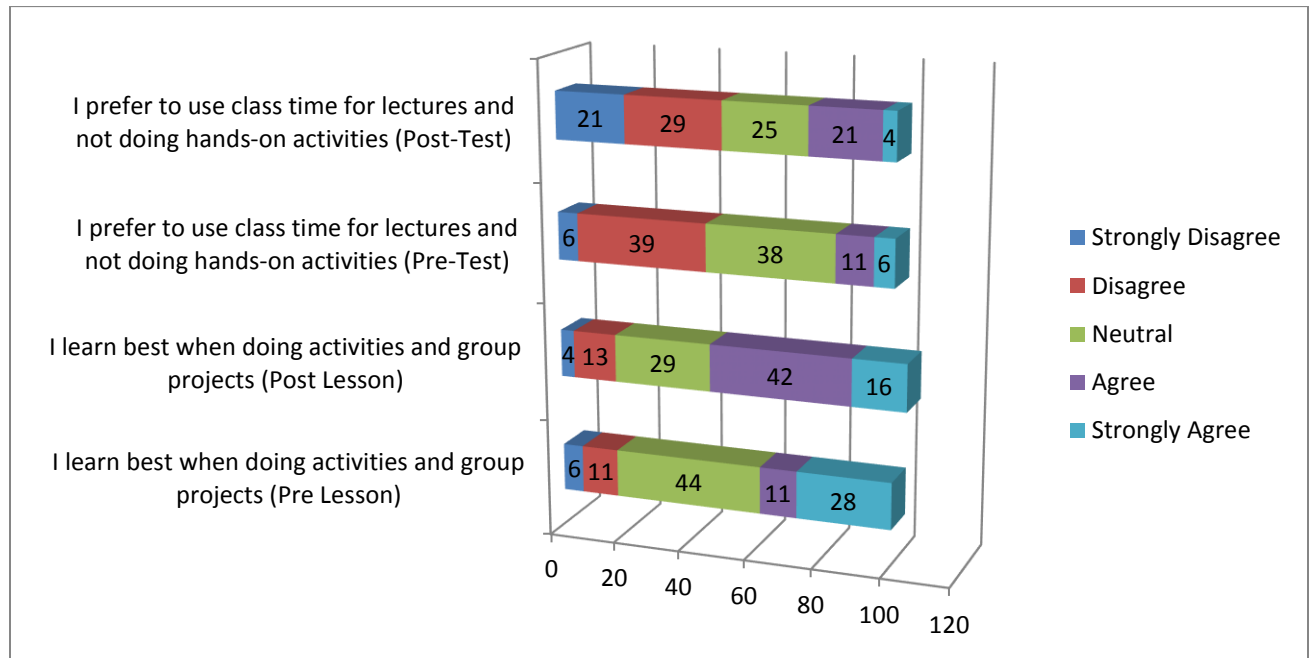


Figure 6. Students responses from the pre-lesson student survey and post-lesson student survey, (N=26).

I feel engaged in class when I am working on group and hands-on activities was the statement that saw the least amount of change in the pre and post treatment. Prior to treatment, 49% of the students agreed with the statement. That percentage rose slightly to 58% post treatment. Some students who originally strongly agreed with this statement only agreed post treatment. Overall, the students that agreed or strongly agreed with the statement fell slightly from 77% to 75% (Figure 7).

The students had very mixed emotions when giving their opinion of the statement, *I feel that watching a video is an effective way to learn new material*. About one fourth of the class was neutral on the statement both before and after the treatment. The amount

of students that disagreed with the statement rose from 21% to 33%. This was the most significant change in the pre and post data. After the treatment, 46% of the students felt that watching videos was not an effective teaching tool, which was up from 37% pre-treatment (Figure 7).

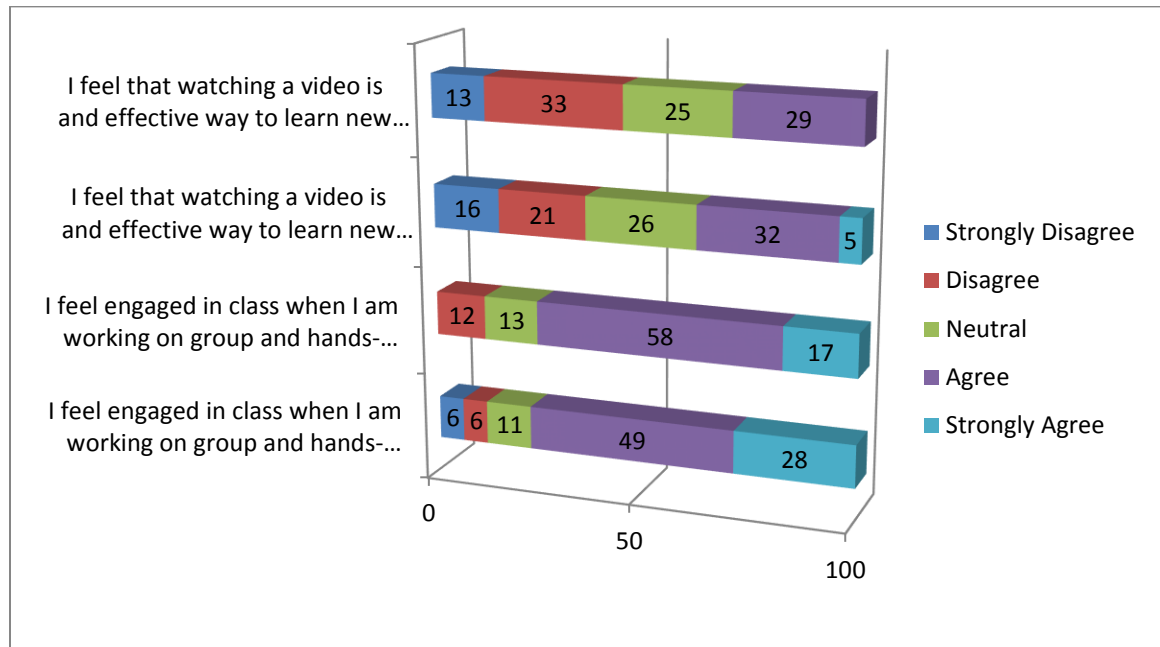


Figure 7. Students responses from the pre-lesson student survey and post-lesson student survey student survey, (N=26).

During the Post Lesson Student Survey, questions were included that could not be included in the Pre Lesson survey. One such question was simply, *I enjoyed the flipped lesson*. Fifty percent of the class was neutral on the topic while 25% of the class agreed they enjoyed the flipped lesson. When asked if they enjoyed flipped lesson, one student replied, “Yes and No because I like to be able to go back and look at them, but sometimes I’d rather just have a teacher teach me,” (Figure 8).

Students had varied opinions on the question, *I learned better doing activities in class than I did from face to face lecture*. More than one third of the class was neutral on

the topic while only 21% disagreed with the statement. Of the group surveyed, 42% percent indicated that they agreed with the statement. One student replied, “I think I learn better because that is the way I am used to learning” (Figure 8).

I feel like more time should be used reviewing video material in class before starting activities was a statement with which only one-fourth of the class could disagree. Forty-two percent of the students agreed that more time needed to be spent reviewing. “I felt like there were some things that I really needed help with but I didn’t want to ask,” replied a male student (Figure 8).

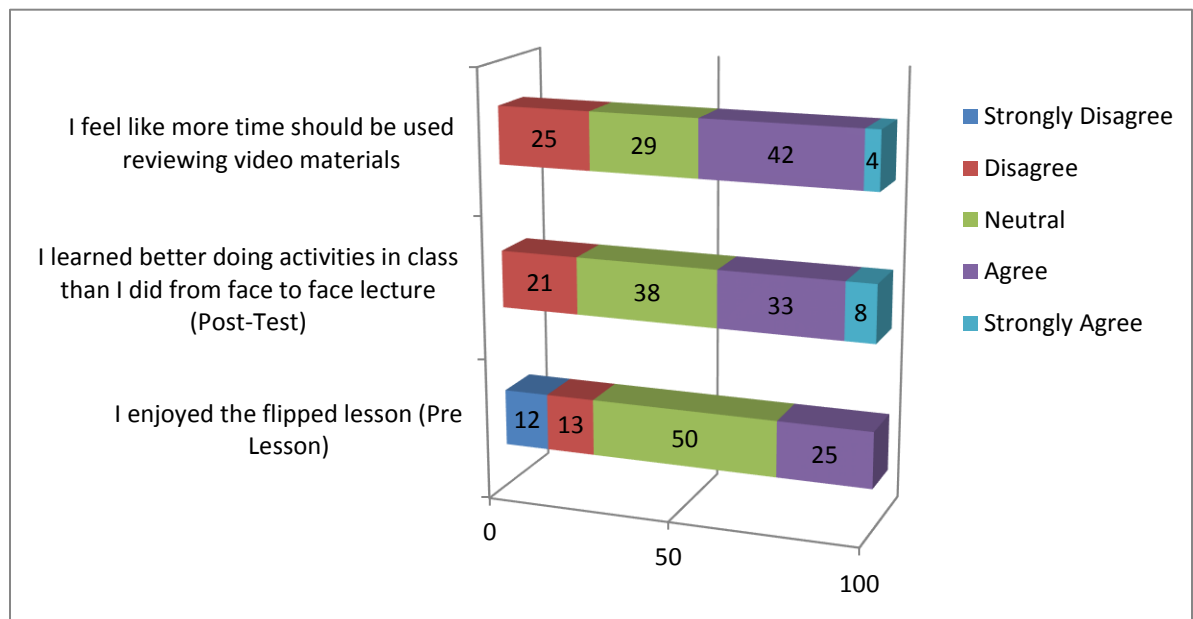


Figure 8. Student responses to select questions on post-lesson student survey, (N=26).

Forty-seven percent of the students felt that they did not learn the material more thoroughly using the flipped model. When responding to the question, *Do you feel you learned the material more thoroughly using the flipped model*, 44% percent agreed with the statement while nine percent of the class was neutral. “I learned it better through the

videos because I could go back and replay them whenever I needed to,” commented one student when asked about the flipped model (Figure 9).

When asked whether or not they watched the video at all, 85% of the class replied that they had watched the video. This data is important when assessing the effectiveness of the lesson. Of the 15% that did not watch the videos, one student replied, “I felt like I knew the information and didn’t really need to watch” (Figure 9).

Sixty percent of the test group agreed or strongly agreed to the statement, *I watched the video on the due date or before*. Forty percent of the class indicated that they did not watch the video on or before the due date. When you subtract the number of students who did not watch the video at all, this number drops to 25%. This implies that three fourths of the test group came to class prepared (figure 9).

When asked if the students watched the video more than one time, 61% of the students either disagreed or strongly disagreed with the question. “I really didn’t need to watch it more than once, I got it the first time,” was the comment of one student about watching the videos. Of the 39% of students that watched the videos more than once, a common reply was, “I watched it the day before it was due and again the night before the test” (Figure 9).

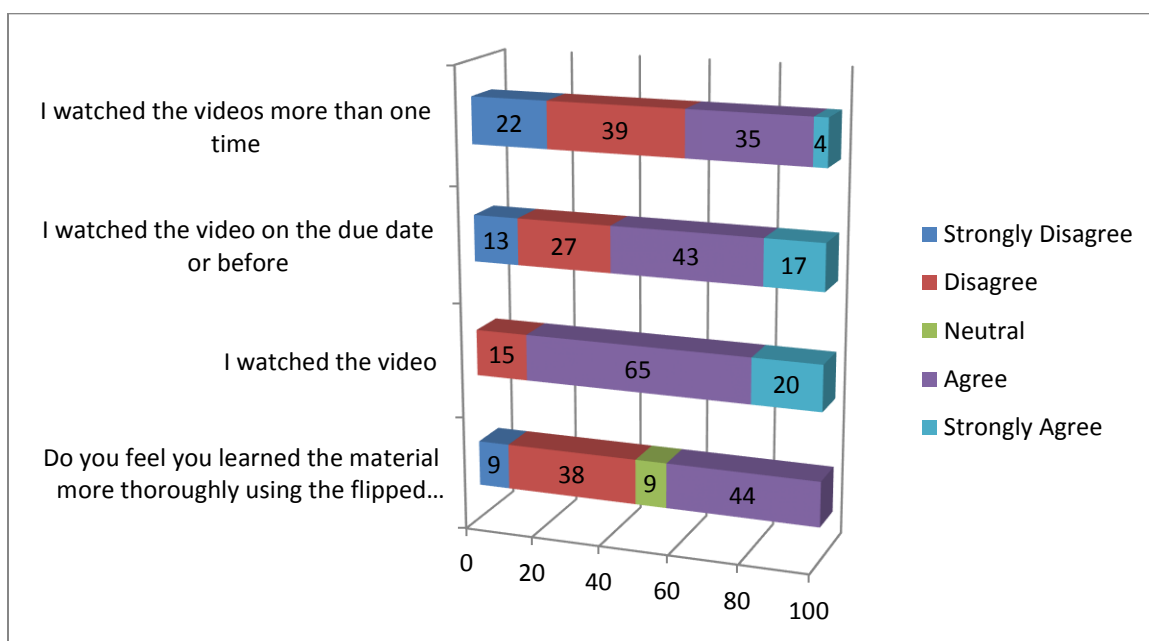


Figure 9. Student responses to select questions on the post-lesson student survey, (N=26).

INTERPRETATION AND CONCLUSION

My primary question for this project dealt with the academic achievement of the flipped teaching method versus that of the traditional classroom setup. The results of the treatment showed that the flipped lesson had a definite impact on student learning for both the mole unit as well as the naming compounds unit. The median of both units went up more than fifty percentage points, which shows substantial growth. When compared to the median of the same two units taught using traditional teaching methods, there was very little difference in the impact. The overall improvement using the flipped model was 57% compared to 57.5% growth using traditional methods. The normalized gains of the mole unit taught using the flipped method showed a gain of .91, which is considered high. The same unit was taught using traditional method and experienced a normalized gain of .84. While both are considered very good gains, the flipped model showed that

students were able to increase their grades seven percent more than those using the traditional model. The naming unit showed a smaller difference in the normalized gains between the two lessons. The flipped lesson had a gain of .93 compared to a .91 gain for the traditional method. This is overall a small difference; however, it does show that the flipped method was more effective in this study group. When determining the overall academic effectiveness of the flipped method of teaching, consideration has to be given to the fact that not all students engaged in watching the videos. Growth was achieved by all students, with none increasing their percentage correct by less than 33 points and with the low normalized gain of .825. Growth in this case would fall in the high range, which indicates that students were able to acquire the skills necessary to be successful by completing the in-class activities and from the questions asked by students about the video. From this data, it appears that both teaching methods are equally effective.

My secondary question was, *Did the flipped classroom have a positive effect on student attitudes toward learning chemistry?* The results of the Pre and Post- Lesson Student Surveys revealed that the majority of the students, 83%, had a positive attitude toward chemistry prior to the treatment. This increased to 85%, which does indicate a small gain. Prior to the treatment, three-fourths of the class said that they felt that they learned better in a face to face lecture environment; however, they also indicated that they felt engaged while working in groups or during hands-on activities. As I observed the students, I felt as if they enjoyed the activities and labs. Learning was taking place, but the students were also having fun. Often in the lecture format, I see students trying to stay awake and engaged. One student commented, “I like being able to play games and do more labs.” From the data collected, it was clear that students enjoyed the activities,

but there were parts of the traditional method they preferred as well. Fifty percent of the class did not feel that watching a video was the most effective way of learning material. The majority also replied that they felt more time should be spent reviewing the material before starting the activity. Putting these results together, one could infer that while the activities are different learning experiences, students need and are used to more teacher interaction. Based on observations of students and results of the surveys, I believe that students gained confidence and flipped classroom did indeed have a positive effect on the student attitudes toward chemistry.

VALUE

The value of this study for me is that the flipped classroom is a method I am exploring in order to use class time as efficiently as possible. This method did allow me to conduct more hands-on activities, while the level of instruction stayed consistent or in some cases improved.

One area that I failed to address in this study was the accountability of the students watching the video. Fifteen percent of the class indicated that they never watched the video. My original intention was to have the students fill in guided notes over the course of the lesson and use them on a quiz on the due date. Without the accountability piece, some students did not see the need to watch the video. Forty percent of the group saw the value of the videos and watched them multiple times. In order for this technique to be most effective, more students should view the video as a valuable learning tool. “I fast forwarded the video to the sections that I needed to be refreshed on. I liked the fact that I could watch it at my own pace,” replied a student when asked what she liked best about the flipped classroom.

In order for the flipped classroom to be most effective, I believe it should be used in conjunction with traditional teaching methods. In my case, I feel that more time should be spent discussing the videos on the due date. It was obvious from the student surveys that more discussion is needed to allow the students to become more comfortable with the topics presented in the videos. The addition of the accountability piece will also help to insure that students are doing their part as they would with traditional homework. No one technique is perfect for everyone, but by incorporating pieces from various methods, it is possible to find the correct balance for each group of students. Judging by the attitudes and excitement of the students during the study, the flipped classroom is definitely a technique I want to continue to explore and modify for use in the future.

Action research should always play a role in the classroom. Many of the strategies that I have used over the years could have been much more effective if I had taken the time to step back and look at what I was doing as a teacher. As a result of this study, I have become more open to trying new techniques but also taking a long look at what I am doing in the classroom. As a 24-year educator, I sometimes find myself being set in my ways. Students are changing, and as an educator I have to be open to techniques that allow students to be more active learners. In the future, I plan to incorporate more flipped lessons into my curriculum, while keeping an open mind for any techniques that encourage student success.

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APPENDICES

APPENDIX A
IRB EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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 Administrator:
 Cheryl Johnson
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MEMORANDUM

TO: Charles Eric Swafford and John Graves
FROM: Mark Quinn, Chair *Mark Quinn*
DATE: November 17, 2015
RE: "What are the Effects of the Flipped Classroom on the Academic Achievement of Chemistry Students?"
 [CS111715-EX]

The above research, described in your submission of November 17, 2015, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

THE MOLE PRE-TEST

The Mole Pre-Test

1. The number of atoms in a mole of any pure substance is called
 - a) its atomic number
 - b) Avogadro's number
 - c) Its mass number
 - d) Its isotopic number
2. The atomic number of oxygen is 8. The atomic number of sulfur is 16. Compared with a mole of oxygen, a mole of sulfur contains
 - a) twice as many atoms
 - b) half as many atoms
 - c) an equal number of atoms
 - d) 8 times as many atoms
3. To determine the molar mass of an element, one must know the element's
 - a) Avogadro constant
 - b) atomic number
 - c) number of isotopes
 - d) average atomic mass
4. Avogadro's number of atoms of any element is equivalent to
 - a) the atomic number of that element
 - b) the mass number of that element
 - c) 6.02×10^{23} particles
 - d) 100 g of that element
5. The mass of 1 mol of chromium is about
 - a) 12 g
 - b) 24 g
 - c) 52 g
 - d) 6.02×10^{23} g
6. A mass of 6.005 g of carbon contains
 - a) 1 mol of C
 - b) 2 atoms of C
 - c) 0.5000 mol of C
 - d) 1 atom of C
7. The mass of 2 moles of oxygen atoms is about
 - a) 16 g
 - b) 32 g
 - c) 48 g
 - d) 64 g
8. What is the number of moles of atoms in 9.03×10^{24} atoms?
 - a) 1.50 mol
 - b) 9.03 mol
 - c) 10.0 mol
 - d) 15.0 mol
9. A sample of tin contains 3.01×10^{23} atoms. The mass of the sample is
 - a) 3.01 g
 - b) 59.3 g
 - c) 72.6 g
 - d) 11g
10. The mass of a sample of nickel is 11.74 g. It contains
 - a) 1.174×10^{23} atoms
 - b) 1.205×10^{23} atoms
 - c) 1.869×10^{23} atoms
 - d) 3.256×10^{23} atoms

11. Which of the following weighs more?
- 1 mole of hydrogen
 - 0.25 moles of He
 - 0.1 mol of Ne
 - 0.2 mol of C
12. What is the molar mass of magnesium chloride, MgCl_2 ?
- 46g/mole
 - 59.763g/mole
 - 95.211g/mole
 - 106.354g/mole
13. What is the molar mass of $(\text{NH}_4)_2\text{SO}_4$?
- 114.09g/mole
 - 118.34g/mole
 - 128.06g/mole
 - 132.13g/mole
14. The molar mass of NO_2 is 46.01 g/mole. How many moles of NO_2 are present in 114.95g?
- 0.4003mol
 - 1.000mol
 - 2.498mol
 - 114.95mol
15. The molar mass of CCl_4 is 153.81g/mol. How many grams of CCl_4 are needed to have 5.000 mol?
- 5.000g
 - 30.76g
 - 769.0g
 - 796.05g
16. How many significant figures in .00340?
- 2
 - 3
 - 4
 - 5
17. How many significant figures in 3400?
- 2
 - 3
 - 4
 - 5
18. What is 2045 rounded to 2 significant digits?
- 20
 - 2000
 - 2050
 - 2.0×10^3

APPENDIX C
THE MOLE TEST

The Mole Test

1. The number of atoms in a mole of any pure substance is called
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 - c) Its mass number
 - d) Its isotopic number
2. The atomic number of oxygen is 8. The atomic number of sulfur is 16. Compared with a mole of oxygen, a mole of sulfur contains
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 - d) 8 times as many atoms
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 - a) Avogadro constant
 - b) atomic number
 - c) number of isotopes
 - d) average atomic mass
4. Avogadro's number of atoms of any element is equivalent to
 - a) the atomic number of that element
 - b) the mass number of that element
 - c) 6.02×10^{23} particles
 - d) 100 g of that element
5. The mass of 1 mol of chromium is about
 - a) 12 g
 - b) 24 g
 - c) 52 g
 - d) 6.02×10^{23} g
6. A mass of 6.005 g of carbon contains
 - a) 1 mol of C
 - b) 2 atoms of C
 - c) 0.5000 mol of C
 - d) 1 atom of C
7. The mass of 2 moles of oxygen atoms is about
 - a) 16 g
 - b) 32 g
 - c) 48 g
 - d) 64 g
8. What is the number of moles of atoms in 9.03×10^{24} atoms?
 - a) 1.50 mol
 - b) 9.03 mol
 - c) 10.0 mol
 - d) 15.0 mol
9. A sample of tin contains 3.01×10^{23} atoms. The mass of the sample is
 - a) 3.01 g
 - b) 59.3 g
 - c) 72.6 g
 - d) 11g
10. The mass of a sample of nickel is 11.74 g. It contains
 - a) 1.174×10^{23} atoms
 - b) 1.205×10^{23} atoms
 - c) 1.869×10^{23} atoms
 - d) 3.256×10^{23} atoms

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 - 128.06g/mole
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- 0.4003mol
 - 1.000mol
 - 2.498mol
 - 114.95mol
15. The molar mass of CCl_4 is 153.81g/mol. How many grams of CCl_4 are needed to have 5.000 mol?
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 - 769.0g
 - 796.05g
16. How many significant figures in .00340?
- 2
 - 3
 - 4
 - 5
17. How many significant figures in 3400?
- 2
 - 3
 - 4
 - 5
18. What is 2045 rounded to 2 significant digits?
- 20
 - 2000
 - 2050
 - 2.0×10^3

APPENDIX D
BONDING PRETEST

Bonding PreTest

Name _____

- 1) Metals tend to _____ electrons and nonmetals tend to _____ electrons.
A) gain, gain B) lose, lose C) lose, gain D) gain, gain E) neither, they keep their electrons
- 2) Anions tend to have a _____ charge and cations tend to have a _____ charge.
A) positive, positive B) negative, negative C) positive, negative D) negative, positive
- 3) _____ typically form ions with a 2+ charge.
A) Alkaline earth metals B) Alkali metals C) Halogens E) Transitions metals
- 4) Sodium forms an ion with a charge of _____.
A) 1+ B) 2+ C) -1 D) 2- E) 0
- 5) Aluminum forms an ion with a charge of _____.
A) 2+ B) 1- C) -3 D) +3 E) +6
- 6) Oxygen forms an ion with a charge of _____.
A) 2- B) 2+ C) -3 D) +3 E) +6
- 7) How many electrons does the Al^{3+} ion possess?
A) 16 B) 10 C) 6 D) 0 E) 13
- 8) What group in the periodic table would the fictitious element $\text{:}\ddot{\text{X}}\text{:}$ be found?
A) Alkaline Earth metals B) Halogens C) Chalcogens D) Alkali metals E) Transition metals
- 9) Which of the following compounds would you expect to be ionic?
A) SF_6 B) H_2O C) CO_2 D) NH_3 E) CaO
- 10) Which pair of elements is most likely to form an ionic compound with each other?
A) barium, Chlorine
B) calcium, sodium
C) oxygen, fluorine
D) sulfur, carbon
E) nitrogen, hydrogen
- 11) Of the choices below, which one is not an ionic compound?
A) PCl_5 B) CrCl_6 C) RbCl D) PbCl_2 E) NaCl
- 12) What is the formula of the compound formed between strontium ions and nitrogen

ions?

- A) SrN B) Sr_3N_2 C) Sr_2N_3 D) SrN_2 E) SrN_3
- 13) Predict the formula of the ionic compound that forms from Calcium and Fluorine.
A) CaF_2 B) C_2F C) Ca_2F_2 D) Ca_2F_3 E) Ca_3F_2
- 14) Predict the formula of the ionic compound that forms from aluminum and oxygen.
A) AlO B) Al_3O_2 C) Al_2O_3 D) AlO_2
- 15) The correct name for SO_2 is _____.
A) strontium oxide B) sulfur dioxide C) sulfur oxide D) monosulfur dioxide
- 16) The correct name for K_2S is _____.
A) potassium sulfate D) potassium sulfide
B) potassium disulfide E) dipotassium sulfate
C) potassium bisulfide
- 17) The correct name for Al_2O_3 is _____.
A) aluminum oxide D) aluminum hydroxide
B) dialuminum oxide E) aluminum trioxide
C) dialuminum trioxide
- 18) The charge on the manganese in the salt MnCl_3 is _____.
A) $1+$ B) $2+$ C) -1 D) $2-$ E) $+3$
- 19) Chromium and chlorine form an ionic compound whose formula is CrCl_3 . The name of this compound is _____.
A) chromium chlorine C) chromium(III) chloride
B) monochromium trichloride D) chromium(III) trichloride
- 20) The correct formula of iron(III) bromide is _____.
A) FeBr_2 B) FeBr_3 C) FeBr D) Fe_3Br_3 E) Fe_3Br
- 21) The correct formula for trichlorine tetraoxide.
A) Cl_3O_4 B) Cl_3O_5 C) Cl_4O_3 D) $\text{Cl}^{+3}\text{O}^{-5}$
- 22) The ions Ca^{2+} and PO_4^{3-} form a salt with the formula _____.
A) CaPO_4 B) $\text{Ca}_2(\text{PO}_4)_3$ C) Ca_2PO_4 D) $\text{Ca}(\text{PO}_4)_2$ E) $\text{Ca}_3(\text{PO}_4)_2$
- 23) What is the correct formula for ammonium sulfide?
A) NH_4SO_3 B) $(\text{NH}_4)_2\text{SO}_4$ C) $(\text{NH}_4)_2\text{S}$ D) NH_3S E) N_2S_3
- 24) The formula for aluminum hydroxide is _____.
A) AlOH B) Al_3OH C) $\text{Al}_2(\text{OH})_3$ D) $\text{Al}(\text{OH})_3$ E) Al_2O_3
- 25) The name of the ionic compound $(\text{NH}_4)_3\text{PO}_4$ is _____.
A) ammonium phosphate C) ammonia phosphide
B) tetrammonium phosphate D) nitrogen hydrogen phosphate
- 26) Covalent bonds are made up of two or more
A) Atoms B) metals C) transition metals D) nonmetals
- 27) What is the name of the following compound- N_3P_2
A) Nitrogen phosphide C) Trinitrogen diphosphide
B) Dinitrogen Triphosphide D) Nitrous
- 28) What is the correct formula for sulfur pentachloride
A) SuP_4 B) S_5P C) SPO_4 D) SP_5

APPENDIX E
BONDING/NAMING TEST

Bonding/Naming Test

Name _____

1. Metals tend to _____ electrons and nonmetals tend to _____ electrons.
 B) gain, gain B) lose, lose C) lose, gain D) gain, gain E) neither, they keep their electrons
1. Anions tend to have a _____ charge and cations tend to have a _____ charge.
 a. positive, positive B) negative, negative C) positive, negative D) negative, positive
2. _____ typically form ions with a 2+ charge.
 a. Alkaline earth metals B) Alkali metals C) Halogens E) Transitions metals
3. Sodium forms an ion with a charge of _____.
 a. 1+ B) 2+ C) -1 D) 2- E) 0
4. Aluminum forms an ion with a charge of _____.
 a. 2+ B) 1- C) -3 D) +3 E) +6
5. Oxygen forms an ion with a charge of _____.
 a. 2- B) 2+ C) -3 D) +3 E) +6
6. How many electrons does the Al^{3+} ion possess?
 a. 16 B) 10 C) 6 D) 0 E) 13
7. What group in the periodic table would the fictitious element $\text{:}\ddot{\text{X}}\text{:}$ be found?
 a. Alkaline Earth metals B) Halogens C) Chalcogens D) Alkali metals E) Transition metals
8. Which of the following compounds would you expect to be ionic?
 B) SF_6 B) H_2O C) CO_2 D) NH_3 E) CaO
9. Which pair of elements is most likely to form an ionic compound with each other?
 F) barium, Chlorine
 G) calcium, sodium
 H) oxygen, fluorine
 I) sulfur, carbon
 J) nitrogen, hydrogen
10. Of the choices below, which one is not an ionic compound?
 B) PCl_5 B) CrCl_6 C) RbCl D) PbCl_2 E) NaCl
11. What is the formula of the compound formed between strontium ions and nitrogen ions?
 B) SrN B) Sr_3N_2 C) Sr_2N_3 D) SrN_2 E) SrN_3

12. Predict the formula of the ionic compound that forms from Calcium and Fluorine.
 B) CaF_2 B) C_2F C) Ca_2F_2 D) Ca_2F_3 E) Ca_3F_2
13. Predict the formula of the ionic compound that forms from aluminum and oxygen.
 B) AlO B) Al_3O_2 C) Al_2O_3 D) AlO_2
14. The correct name for SO_2 is _____.
 B) strontium oxide B) sulfur dioxide C) sulfur oxide D) monosulfur dioxide
15. The correct name for K_2S is _____.
 D) potassium sulfate D) potassium sulfide
 E) potassium disulfide E) dipotassium sulfate
 F) potassium bisulfide
16. The correct name for Al_2O_3 is _____.
 D) aluminum oxide D) aluminum hydroxide
 E) dialuminum oxide E) aluminum trioxide
 F) dialuminum trioxide
17. The charge on the manganese in the salt MnCl_3 is _____.
 a. 1+ B) 2+ C) -1 D) 2- E) +3
18. Chromium and chlorine form an ionic compound whose formula is CrCl_3 . The name of this compound is _____.
 C) chromium chlorine
 D) chromium(III) chloride
 E) monochromium trichloride
 F) chromium(III) trichloride
19. The correct formula of iron(III) bromide is _____.
 B) FeBr_2 B) FeBr_3 C) FeBr D) Fe_3Br_3 E) Fe_3Br
20. The correct formula for trichlorine tetraoxide.
 a. Cl_3O_4 B) Cl_3O_5 C) Cl_4O_3 D) $\text{Cl}^{+3}\text{O}^{-5}$
21. The ions Ca^{2+} and PO_4^{3-} form a salt with the formula _____.
 B) CaPO_4 B) $\text{Ca}_2(\text{PO}_4)_3$ C) Ca_2PO_4 D) $\text{Ca}(\text{PO}_4)_2$ E) $\text{Ca}_3(\text{PO}_4)_2$
22. What is the correct formula for ammonium sulfide?
 B) NH_4SO_3 B) $(\text{NH}_4)_2\text{SO}_4$ C) $(\text{NH}_4)_2\text{S}$ D) NH_3S E) N_2S_3
23. The formula for aluminum hydroxide is _____.
 B) AlOH B) Al_3OH C) $\text{Al}_2(\text{OH})_3$ D) $\text{Al}(\text{OH})_3$ E) Al_2O_3
24. The name of the ionic compound $(\text{NH}_4)_3\text{PO}_4$ is _____.
 C) ammonium phosphate
 D) tetrammonium phosphate
 E) nitrogen hydrogen phosphate
 F) ammonia phosphide
 G) triammonium phosphate
25. Covalent bonds are made up of two or more

A) Atoms B) metals C) transition metals D) nonmetals

26. What is the correct formula for sulfur pentachloride

a. SuP_4 B) S_5P C) SPO_4 D) SP_5

Formula	Structure	Shape (Geometry)	XXXXXXXXXXXXX
PCl_5			XXXXXXXXXXXXX
SF_4			XXXXXXXXXXXXX
SF_6			XXXXXXXXXXXXX
ClF_3			XXXXXXXXXXXXX
I_3^-			XXXXXXXXXXXXX
BrF_5			Hybridization
XeF_4			Hybridization

APPENDIX F
PRE-LESSON STUDENT SURVEY

Pre-Lesson Student Survey

Participation in this survey is voluntary.

1. I currently like chemistry.

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

2. I learn best in a face to face lecture environment.

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

3. I learn best when doing activities and group projects.

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

4. I prefer to use class time for lectures and not doing hands-on or group activities.

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

5. I feel more engaged in class when I am working on group or hands-on activities.

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

6. I feel that watching a video is an effective way to learn new material.

27. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

APPENDIX G
POST-LESSON STUDENT SURVEY

Post-Lesson Student Survey

3. I currently like chemistry.
1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
4. I learn best in a face to face lecture environment.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
3. I learn best when doing activities and group projects.
2. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
4. I prefer to use class time for lectures and not doing hands-on or group activities.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
5. I feel more engaged in class when I am working on group or hands-on activities.
1. a Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
6. I feel that watching a video is an effective way to learn new material.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
7. I enjoyed the flipped lesson.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
8. I would like more lessons to be flipped in the future.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
1. I feel like more time should be used reviewing video material in class before starting activities.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
10. I watched the videos more than one time.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
11. Do you feel you learned the material more thoroughly using the flipped model.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
12. I watched the video on the due date or before.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
13. I crammed and watched the video on the day of the test.
1. Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

APPENDIX H
STUDENT INTERVIEW QUESTIONS

Student Interview Questions

Participation in this survey is voluntary.

1. Do you feel like you learned as much watching the videos as you would in the traditional classroom? Explain.
2. Would you rather have lesson taught traditionally or using the flipped method? What do you like most about your choice?
3. What are some things you like about the flipped lesson? What are some things you didn't like?
4. How much time did you spend watching the videos? How did you feel about the length of the videos?
5. Was the additional class time to work on problems with the teacher present beneficial?
6. Is there anything you would change about the flipped classroom?
7. Is there anything you would want me to know?