

THE EFFECTS OF THE FLIPPED CLASSROOM INSTRUCTIONAL MODEL ON
STUDENT OUTCOMES IN A NINTH GRADE EARTH AND
SPACE SCIENCE CLASSROOM

by

Heather Renyck

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2015

©COPYRIGHT

by

Heather Renyck

2015

All Rights Reserved

ACKNOWLEDGMENTS

I would not have successfully completed this project without assistance, support and guidance from my MSSE advisor, Walt Woolbaugh, to whom I am especially thankful. I am extremely grateful for the congenial, supportive, and patient group of ninth graders who participated in this study: Bolivar-Richburg Central School District's Class of 2018. Thanks to colleagues Lisa Chapman and Eric Baldwin who generously shared their time and wisdom regarding their flipped classroom experiences. Thanks to Dr. Jerry Nelson of Casper College in Wyoming for taking the time to be my science reader. Retired New York State science teacher, Marion Weaver, patiently and promptly reviewed my drafts in spite of my sporadic email communication. Her advice was invaluable. My editor, Nicki Prevost, contributed to my work by redirecting my bias and helping me think differently and more creatively. To Leah Kirnan, my special education push-in teacher, I am a better teacher and person as a result of our daily consultations. Thanks to Dr. Peggy Taylor, MSSE director and Diana Patterson, MSSE associate director. Both made the entire process leading up to and including graduation easier to navigate. I would be remiss if I did not acknowledge my friends and family – especially my father, Paul Renyck - for their support and understanding when I missed events and time with them due to my academic commitments. Finally, thanks to my partner, Jim Bromley, for occasionally competing with Montana State University for my time.

TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND	1
2. CONCEPTUAL FRAMEWORK	6
3. METHODOLOGY	10
4. DATA AND ANALYSIS	17
5. INTERPRETATION AND CONCLUSION	36
6. VALUE	41
REFERENCES CITED	44
APPENDICES	46
APPENDIX A: Pre- and Post-unit Assessment for Treatment Unit	47
APPENDIX B: Pre- and Post-unit Assessment for Non-treatment Unit	56
APPENDIX C: Post-unit Interview questions for Non-treatment Unit	66
APPENDIX D: Post-unit Interview questions for Treatment Unit	68
APPENDIX E: Sample CAT for Non-treatment Unit	70
APPENDIX F: Sample CAT for Treatment Unit	72
APPENDIX G: Post-unit Survey for Non-treatment Unit	74
APPENDIX H: Post-unit Survey for Treatment Unit	76
APPENDIX I: Sample of Teacher Journal Entry for Non-treatment Unit	78
APPENDIX J: Sample of Teacher Journal Entry for Treatment Unit	80
APPENDIX K: General Timeline	83
APPENDIX L: IRB exemption application and CITI certificate	85
APPENDIX M: Non-content-related Interview Questions and Responses for Post Non-treatment Unit	87
APPENDIX N: Non-content-related Interview Questions and Responses for Post-treatment Unit	90

LIST OF TABLES

1. Non-treatment and Treatment Plans	13
2. Data Triangulation Matrix	14
3. Content-related Interview Questions for Post Non-treatment Unit	26
4. Answers to Content-related Interview Questions for Post Non-treatment Unit	27
5. Content-related Interview Questions for Post-treatment Unit	27
6. Answers to Content-related Interview Questions for Post-treatment Unit	28
7. Results from CATs for Non-treatment Unit	29
8. Results from CATs for Treatment Unit	29
9. Survey Questions for Post Non-treatment Unit with Results	31
10. Survey Questions for Post-treatment Unit with Results	33

LIST OF FIGURES

1. Comparison Between Non-treatment and Treatment Growth on Content Assessments for All Students.....	18
2. Comparison Between Non-treatment and Treatment Growth on Content Assessments for High-achieving Students	19
3. Comparison Between Non-treatment and Treatment Growth on Content Assessments for Average-achieving Students.....	20
4. Comparison Between Non-treatment and Treatment Growth on Content Assessments for Below Average-achieving Students	21
5. Comparison Between Non-treatment and Treatment Growth on Content Assessments for IEP and 504 Students	22
6. Comparison Between Non-treatment and Treatment Growth on Content Assessments by Gender.....	23
7. Comparison Between Non-treatment and Treatment Growth on Content Assessments by Average-achieving Females and Below Average-achieving Females.....	24
8. Comparison Between Non-treatment and Treatment Growth on Content Assessments by Above Average-achieving Males, Average-achieving Males and Below Average-achieving Males	25

ABSTRACT

Physical Setting Earth Science in New York State is an appreciation course with a curriculum of great breadth and moderate depth. New York State requires a high stakes exit exam that all students must pass in order to receive their academic diploma. The assessment is content and reading-comprehensive, and it requires that students use a 16-page reference table to interpret graphs and charts for about 40% of the questions. Many teachers find it difficult to treat all sections of the curriculum with the time that it deserves unless they are simply teaching to the test. Some of the content is too abstract for many ninth grade students, thus considerable time should be spent on practice in class. Practicing with students in class burns time that teachers would normally use to deliver information.

The Flipped Classroom Instructional Model was designed to deliver the traditional classroom lecture through a video screencast as a homework assignment. Students are told to watch videos at home, take good notes, write down any question that they have, and come to class the following day prepared to have their questions answered and to practice the concepts. Could this model work for a ninth grade Physical Setting Earth Science class in rural, western New York?

Data collection for this project included two weeks of traditional classroom teaching methods for the non-treatment unit, delivering content about relative age in geologic time. It also included two weeks of implementing the Flipped Classroom Instructional Model for the treatment unit, delivering content about absolute age dating methods in geologic time. Instruments used included pre-and post unit content assessments, classroom assessment techniques, surveys, interviews, and journals.

Results revealed that flipping the classroom was most beneficial to students with Individualized Education Plans, below-average achieving males, and average-achieving females. Above-average students showed marginal benefits. Below-average achieving females and average-achieving males did not appear to benefit from the treatment.

INTRODUCTION AND BACKGROUND

Teaching Goals and State Mandates

The topic of this project is discovering the effects of using the Flipped Classroom Instructional model on students' understanding of Earth science concepts. My primary teaching goal is to deliver a general appreciation of Earth science in a way that is meaningful to students so that they might acquire and strengthen basic skills through science discovery. The goal includes inspiring students to embark on a journey of life-long learning. It is a lofty goal that I have observed to be shared by many teachers, and, in my opinion, it is challenging to meet this goal with a high-stakes, mandatory, state exam as the main assessment for the course. Much time is devoted to developing lessons to engage students in my classroom, but I have an obligation to my students to ensure that they are prepared for their exit exam which is necessary to be rewarded credits for the New York State Regents Diploma (The Board of Regents in New York State oversees all public education within the state). While a Regents Diploma is not mandatory for graduation, it is required for students planning to attend a public university within New York State. Consequently, students who want to attend an institution of higher education need to pass the Physical Setting Earth Science exam. Another high stakes factor to consider is that 40% of a teacher's evaluation in New York State is dependent on their students passing a state exam. This places added pressure on the teacher to get students invested and excited about their education. While that could be viewed as good, it is especially hard to achieve in regions of the state where students have had a rough start in

life whether it be their experience with “broken” homes, violence in the home, negligence, poverty, refugee status, etc.

School and Classroom Demographics

Bolivar-Richburg Central School District is a small, regional school containing about 450 students in grades 6 through 12. It is located in rural, southwestern New York, and it services the towns of Bolivar, Ceres, Little Genesee, Richburg, and West Clarksville in Allegany County. Ninety-seven percent of the students are of Caucasian ethnicity. The remaining 3% of students are of Native American, African American, or Hispanic ethnicities. Fifty-seven percent of the students are eligible for free or reduced lunch. Finding and keeping permanent work in Allegany County is a problem, as little economic growth exists. Consequently, a small percentage of students leave and return to the district in a given school year. This leads to small gaps in their education.

Participants involved with this project include 63 students in four heterogeneously grouped sections of Physical Setting Earth Science in Grade 9. There are more females than males in this class, 59% and 41% respectively. Each class is 42 minutes long and meets every day. The course runs from September 3, 2014 through June 12, 2015. All students in Grade 9 are required to take this course. The students in these classes have a wide range of academic abilities with 11% of them having Individualized Education Plans (IEPs) addressing specific learning disabilities. Six percent of the students have 504 Plans (special accommodations without identification of a learning disability). On their eighth-grade Language Arts state assessment, only 66% of females and 37% of males met New York State’s proficiency standard. This means that 34% of females and

63% of males were at basic or below basic proficiency in Language Arts. No student performed below basic proficiency on the eighth-grade New York State science assessment.

Focus Question

I teach four sections of Physical Setting Earth Science class and four sections of Physical Setting Earth Science lab. The state has created a 16-page reference document that contains tables and charts that students can access during their final exam for the Physical Setting Earth Science exam. In fact, on average, 35 – 40% of the test answers are found by interpreting these charts. Teachers, therefore, are encouraged to use this reference regularly during the school year. Some of the charts and graphs require extensive explanation before using them with practice problems and laboratory experiences. Teachers underestimate the attention needed to get all students to learn how to effectively interpret graphs and charts. Tairab and Al-Naqbi (2010) discovered that students in their tenth grade biology class were able to interpret small sections of charts, but that they often missed the bigger picture. Additionally, results from their study revealed that frequent exposure to many types of graphs and charts was needed for students to better interpret charts and graphs. I often find myself running out of time to effectively practice using the charts and graphs with my students. If I “flip” my classroom, will the time gained for practice yield a better understanding of Earth science concepts and use of these charts and graphs?

My primary action research question is “What are the effects of using a flipped classroom with a high school Earth science class?” My sub questions are as follows:

1. What are the effects of flipping the classroom on students' understanding of Earth science concepts and students' ability to interpret data tables and graphs?
2. What are the effects of flipping the classroom on students' attitudes in science class?
3. What are the effects of flipping the classroom on the teacher?

A "flipped classroom" is one in which the student watches short videos of teacher lectures for homework. Students take guided notes on these videos after class hours. Students practice concepts with the teacher during class on the following day. The traditional method typically sent a student home to practice concepts on her/his own. This can lead to confusion, especially with more challenging concepts. An additional problem at my school is that many students do not thoroughly complete their homework (and in some cases not attempt it all, regardless of the effects on their grade). The point is to complete the practice in class so that students can ask questions when they are struggling with practice problems/tasks (and to be sure that the practice occurs). Since the exit exam requires strong reading comprehension skills, watching videos at home might also make time for the use of more reading comprehension strategies during class.

It appears to me that educators at all levels are divided with respect to their feelings about the effectiveness of the Regents curriculum. On the one hand, there is a standard that everyone needs to follow. This can be good, for it serves as a baseline and foundation for all teachers, but at what cost? Many would say that the standardized testing stifles creativity, critical thinking, and problem solving. As my feelings evolve on this matter, one thing I know for certain: for decades at Bolivar-Richburg Central School

District, we have had an average passing rate on the Physical Setting Earth Science exam of 75-80%. In some subject areas the passing rate is better and in others it is worse. This year, for example, based on the average passing rate on Physical Setting Earth Science exams thus far, it is possible that only 60% of this year's group will pass their exit exam. Administrators and teachers in my district have a vested interest in exploring methods employed in this study because they share similar goals for the students and their courses have similar exit exams. Collectively, we need to improve basic skills that our students, on average, do not have and this should serve the students for both developing better conceptual understanding of concepts while helping them to achieve higher test scores. With the Flipped Classroom Instructional Model, teachers should have more time in class to work on the skills that would allow for comprehending difficult material.

A support team was established to assist me with the development of this project. The first member of my support team is a retired science teacher from New York, Marion Weaver. She was a formal teacher mentor for many years after her retirement and stays involved in the changes in public education. She has helped with the mechanics and overall presentation of the project. No price can be placed on the value of her input, for she is a master teacher. The second member of my support group is Leah Kirnan, a direct consultant special education teacher who pushes into my class and lab on a daily basis. Leah knows more about my teaching methods and student outcomes than anyone else in my life, for she experiences it with me. Daily consultation and planning for our class has occurred well before this project began, and it will continue well after this project is over. I could not have completed this work successfully without her. The third member of my

support team is Nicki Prevost, a former hair stylist and life-long learner. Nicki was the creative support for me and helped me to see my lessons in a completely different light. Nicki challenged me to think about teaching and learning in ways that I usually do not. My science content reader is a professor from Casper College Science Department in Wyoming, Jerry Nelson, Ph.D. My MSSE project advisor who is a public junior high school teacher and MSU professor is Walter Woolbaugh, Ph.D.

CONCEPTUAL FRAMEWORK

The roots of the flipped classroom are connected to a combination of constructivism, blended learning, and peer instruction. Constructivism is a philosophy about how people learn, specifically through experience and reflection. In education, this includes the teacher allowing the learners to proceed at their own paces, construct their own understandings through reflection and pre-existing knowledge, and facilitate the learning environment (EBS, 2004). Blended learning refers to an environment using technology outside of the traditional classroom in combination with traditional methods in a physical classroom. Staker & Horn (2012) further define blended learning as “a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path, and/or pace and at least in part at a supervised brick-and-mortar location away from home” (p. 3). Lasry, Mazur, and Watkins (2008) defined peer instruction as “a student-centered approach to teaching that has demonstrated effectiveness in university settings” (p. 1067). This involves having students prepare for class by completing outside readings or something similar. When students come to class, for example, they discuss the content

with each other, solve problems as a group, or engage in a group discussion facilitated by an instructor.

Beginning in 2007, the flipped classroom was popularized by Jonathan Bergmann and Aaron Sams though both authors concede that no one owns the term and that it was largely used in the media to describe the methods that were being used by the authors and others. Bergmann and Sams began working in the same science department in a Colorado high school in 2006. Both teachers were frustrated with the amount of class time that students were missing due to sports events, illness, and extra curricular activities. An additional burden was that students often struggle with some of the advanced concepts in chemistry. Re-teaching concepts to absent and/or confused students was taking up a great deal of their time. Through the advent of platforms like YouTube and screen casting software, Bergmann and Sams decided to try to video record their lessons to make them available online to students who missed classes and to serve as reinforcement to students who needed to go back to lectures for a second listen. Their experimenting led to the idea that assigning videos for homework could free up time in the classroom to practice concepts with students. The method worked so well that they continued to tweak and trouble-shoot, thus making the process smoother through trial and error (Bergmann & Sams, 2012).

According to Bergmann and Sams (2012), a flipped classroom involves assigning the lecture as homework through video instruction and having students practice the concepts from the video in the subsequent class. Students were expected to take notes and record questions that they have to make the time in class more valuable and centered

to their needs. As they became more comfortable with the change from traditional classroom lectures to the flipped setting, Bergmann and Sams took their approach a step further. This led to the “flipped-mastery classroom.” The flipped-mastery classroom (Bergmann & Sams, 2014) included the same aspects as the flipped model, but with flipped-mastery the students worked at their own pace. The result of this approach was a truly differentiated instruction for all students, but it took a lot of time for the teachers to adjust.

Bergmann and Sam (2012) share:

You might ask how we can do so much with so many kids at the same time.

Frankly, this is our struggle. We are constantly moving around the room giving attention to those who need it and making sure that all students are learning what they need when they need it. We have called this our three-ring circus of learning because there are so many different activities happening at the same time.

Though as we look at a typical day, it probably should be called a ten-ring circus.

Teaching in the flipped-mastery model is tiring, and our minds have to constantly switch between one topic and the next, and from one activity to another (p. 54).

The flipped-mastery classroom’s origins are tied to the concepts of mastery learning, a learning model dating back to the 1920s but popularized in the 1950s and 1960s by Benjamin Bloom. The goal was to reduce gaps in students’ understanding of material, knowing that some students learn certain material faster than other students. Components of mastery learning include but are not limited to programmed learning modules for students to work through independently or in small groups at their own pace, teacher

facilitation, one-to-one tutoring, peer instruction, and flexible deadlines to complete work. Bloom (1952) even applied this principle to university diplomas by explaining and defending The University of Chicago's decision in 1942 to award a 4-year Bachelor of Arts diploma to students who left high school in the 10th grade and were admitted to the university sooner than most students. This example allowed Bloom to describe the importance of tools that measured a student's baseline knowledge, the importance of flexibility with learning pace for individuals, differentiation of instruction, and non-traditional methods of relaying information to students inside and outside of the classroom.

Opponents of a self-paced environment claimed that this flexibility led to some middle and high school students lagging behind because they did not have the discipline to complete the work. Teachers who experienced this with their students set flexible deadlines so that students knew that there would be a date to which they had to adhere and have certain units completed. Some opponents objected to the notion that the flipped classroom environment was a novel way of teaching since lectures were just moved from live teacher to recorded video cast. In response, Bergmann stated that these opponents might be missing the point. Lectures can be engaging, and the big benefit from the flip is the ability to work one-on-one and in small groups during class time to be sure that students understand the new material (Ash, 2012).

To review nothing other than the experiences of Bergmann and Sams would be negligent, as there are countless records of success from practicing teachers and professors. For example, a study conducted by Russell Mumper at the University of

North Carolina's Eshelman School of Pharmacy, revealed a 7% increase in student performance on final exams at the end of the third year of treatment. Mumper was skeptical of the flipped classroom model, but he was keen to try it since his students' average on the final exam in his course was consistently around 80% at best. In 2011, Mumper taught his course in the traditional way. In 2012 and 2013, he taught his course using the flipped classroom model. The average score on his final exam was 5% higher by the end of 2013 (Mumper, 2013).

The Khan Academy (2015) has also been leading the way with providing free, online, video lectures that are offered in many languages. The team's mission is to provide a great education to anyone, anywhere, and at anytime with just about any subject. Specialists develop "learning dashboards" for learners that include instructional videos and practice opportunities to meet the level of the learner, fun rewards to keep students engaged along the way, and feedback on the assignments. In short, many companies, school districts, and teachers are investing their time and money with the Flipped Classroom Instructional Model because there is a great deal of research-based evidence to show that it works.

METHODOLOGY

Project Treatment

To answer the focus question and sub-questions, a non-treatment unit and a treatment unit were delivered to the students with the intent to compare student performance. It was my hope that the treatment would help students to learn better and that I would determine this through surveys, interviews, assessments, classroom

assessment techniques (CATs), and conversations with colleagues who are either actively flipping their classrooms or who have in the past. Receiving the qualitative feedback via surveys and interviews was useful, for it allowed me to better understand the mind of the learner as described directly by the learner.

Two units were used in the implementation of this project. The non-treatment unit was Relative Dating Methods in Geology and The Geologic Time Scale. In the Relative Dating section of the unit, students discovered qualitative methods of comparing the ages of rocks and sediments in a sequence. In The Geologic Time Scale portion of the unit, students were exposed to the many variables contained on The Geologic Time Scale as well as what it took to piece it together. During these units, no treatment was administered, and students were given the typical pedagogical methods employed by the teacher including guided notes, hands-on laboratory activities, group discussions, and Regents exam practice questions. The treatment unit was Absolute Age Dating. In this unit students were presented with information about the method of radioactive decay in dating igneous rocks, the role of selective isotope accumulation in the shells of certain phytoplankton for dating sediments, and the role of volcanic ash beds in establishing absolute dates in the rock record. This unit was taught with the Flipped Classroom Instructional Model. The non-treatment and treatment units were compared to determine the effects of the Flipped Classroom Instructional Model on student outcomes, graph and chart interpretation, student attitudes, and teacher attitudes. Incidentally, these units were not chosen by chance or by a hunch on the part of the teacher. For the past four years, students performed equally poorly on these units with only 55% of the students passing

the unit exams for each topic. Due to the poor results of the past combined with how closely linked these topics are, they seemed like obvious choices for a comparison study in action research.

In the non-treatment unit, students took guided notes, completed vocabulary worksheets, completed short practice worksheets, completed pre-lab notes during class, and took a unit exam. In the treatment unit, students watched short, (8-14 minutes in length) teacher-created videos for homework. Students were expected to complete guided notes (template provided by teacher) as they watched. The first video served as a review to students about how to interpret graphs and charts when faced with a new one. In the first video, the radioactive decay data from New York State's Earth Science Reference Table was included as an example of a new chart to interpret. In the second video, students were presented with how radioactive decay works in rocks and how geologists determine which radioactive sample is appropriate for dating their samples. Students were also given information about other absolute age time markers like volcanic ash layers and lake varves. The last video was designed to reinforce and review all of the information. Students were given an open-note quiz as they arrived to class the day after the first two videos. Students were permitted to use their notes to help them with the practice problems that they completed in class. The teacher observed and assisted students in class in lieu of using that time for lecture. Students took a unit exam. Table 1 shows the non-treatment and treatment plans that were followed.

Table 1

Non-treatment & Treatment Plans Followed

Non-treatment Units	Treatment Units
January 19 - Administer unit pre-test.	February 6 – Administer unit pre-test and assign video 1 (with guided sheet) for homework.
January 22 & 23 - Teach lessons in unit (notes, discussion, practice concepts).	February 10 – Give open-note quiz, collect guided sheet, collect quiz, give CAT 1, and practice concepts. Assign video 2.
January 27 – CAT 1 and further practice.	February 11 - Give open-note quiz, collect guided sheet, collect quiz, give CAT 2, and practice concepts. Assign video 3.
January 28 – CAT 2 and further practice.	February 12 - Collect guided sheet, give CAT 3, practice concepts, and review for post-assessment. Try the penny activity in lab.
January 29 & 30 – Deliver more notes and practice.	February 13 – Supposed to be our post-assessment day, but we had a snowstorm followed by winter break.
February 3 – CAT 3 and review for post-assessment.	February 23 – Review for the post-assessment.
February 4 – Post-assessment and survey given.	February 24 – Post-assessment and survey given.

Data Collection Instruments

The focus question and sub-questions were answered by using three data collection sources, to ensure credibility and to reduce bias. The data triangulation matrix includes quantitative and qualitative data from students, colleagues, and teachers for the purpose of comparison between non-treatment and treatment units (Table 2).

Table 2
Data Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> What are the effects of using a Flipped Classroom with a high school Earth science class?	Pre-unit Assessment and Post-unit Assessment with intermittent CATs	Post non- treatment and post treatment student surveys	Post non- treatment and post treatment unit student concept interviews
<i>Secondary Questions:</i> What are the effects of students' understanding of Earth science concepts and students' ability to interpret data tables and graphs?	Pre-unit Assessment and Post-unit Assessment with intermittent CATs and quizzes	Post non- treatment and post treatment student surveys	Post non- treatment and post treatment unit student concept interviews
What are the effects of flipping the classroom on students' attitudes in science class?	Pre and post- treatment student surveys	Teacher observations and weekly reflection journaling	Post non- treatment and post treatment unit student concept interviews
What are the effects of flipping the classroom on the teacher?	Teacher weekly reflection journal entries	Daily record of preparation time necessary for completion of videos, uploading, etc.	Non-treatment and treatment discussions with colleagues who are also flipping their classrooms

The triangulation matrix shows that multiple tools were used to help acquire qualitative and quantitative data and to identify possible inconsistencies. Professionals including qualified colleagues, graduate school professors, and graduate school colleagues assisted with the validity of these tools by editing and offering useful changes. Action research

textbooks were used to assist with the completion of surveys. For example, surveys used to gain information from students before and after non-treatment and treatment units contained a Likert Scale to help quantify results and to identify inconsistencies in student responses. Finally, the pre and post-assessments included Regents exam questions that have been piloted in the field and created by trained professionals.

To answer the focus question, all students were given pre-and post-unit assessments in treatment and non-treatment units to allow for comparison of students' understanding of Earth science concepts between treatment and non-treatment units (Appendices A and B). Student interviews containing content and non-content-related questions were conducted to determine what students remembered from both units (Appendices C and D).

In order to discern the effects of the Flipped Classroom Instructional Model on students' ability to interpret data tables and graphs, students completed a pre- and post-unit assessment for treatment and non-treatment units. Student interviews containing content-related questions were conducted after treatment and non-treatment units to determine students' ability to interpret data and graphs. Analysis of qualitative and quantitative data of classroom assessment techniques (CATs) that were delivered during treatment and non-treatment units was completed to determine if intervention in the treated unit led to fewer mistakes in data interpretation (Appendices E and F). CATs are simple, informal, class activities that take little time to complete but offer valuable information to the teacher and to the student. They are teacher-directed, learner-centered,

mutually beneficial, formative, content-specific, and based on good research (Angelo and Cross, 1993).

In order to evaluate the effects of using the Flipped Classroom Instructional Model on students' attitudes and motivation, student surveys with open-ended questions were given at the end of treatment and non-treatment units (Appendices G and H). Student interviews containing questions that were both related and unrelated to content were conducted after treatment and non-treatment units to help the teacher discover students' attitude and motivation. Content questions were included to act as a secondary measure to determine what students remembered about content. I included both content and non-content-related questions in one interview for scheduling purposes. The students interviewed were from my ninth-grade, heterogeneously grouped Earth science classes. I chose 10 high-achieving students (Group 1), 10 middle-achieving students (Group 2), and 10 low-achieving students (Group 3). These rankings were made based on average performance on quizzes, tests, reading levels on state exams, and homework completion. To determine the effects of using the Flipped Classroom Instructional Model on the teacher's attitude and motivation, teacher reflection journals were analyzed for trends. Analysis of teacher journal entries was used to locate trends, if any, with teacher perception of student motivation (Appendices I and J). Information gained from formal discussions with three colleagues who have experience with Flipped classrooms was studied to compare teacher attitude and motivation in treatment and non-treatment units. Finally, the study was conducted over a seven-week period in the spring of 2015 (Appendix K). 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 L.).

DATA AND ANALYSIS

Pre-unit and post-unit content assessments were given for both treatment and non-treatment units. The results for all students do not show a statistically significant growth between treatment and non-treatment units. Figure 1 shows a boxplot that compares growth for all students for the treatment and non-treatment units. Values on this and all of the boxplots in this paper include (from top to bottom on the box and whisker) quartile 3, the median, and quartile 1. Note that more growth is shown in quartiles 1 and 3 for the treatment units. Furthermore, the median is higher in the treatment unit. The standard deviation was insignificantly higher in the treatment unit. The mean (while not shown on any of the boxplots) was nearly equal between the units. Several outliers exist in the treatment results, but only one outlier is shown in the non-treatment results.

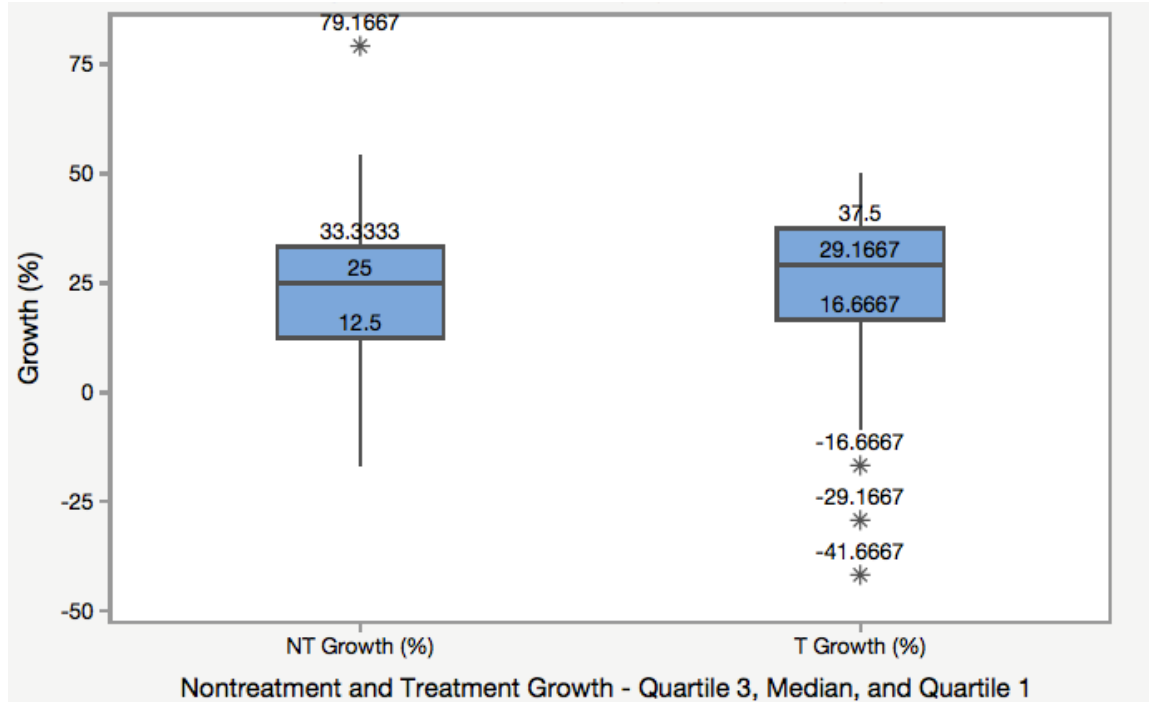


Figure 1. Results showing a comparison between non-treatment and treatment growth on content assessments for all students, ($N=63$).

When students were sorted into groups according to achievement level, the results were different. Above average performers ($n=18$) in the class showed a small benefit from treatment in that the first quartile results were larger in the treatment unit, but the third quartile results were about the same between the units (Figure 2). The median score was 2% higher in the treatment unit, the mean was only 1% higher in the treatment unit, and the standard deviation was slightly lower in the treatment unit.

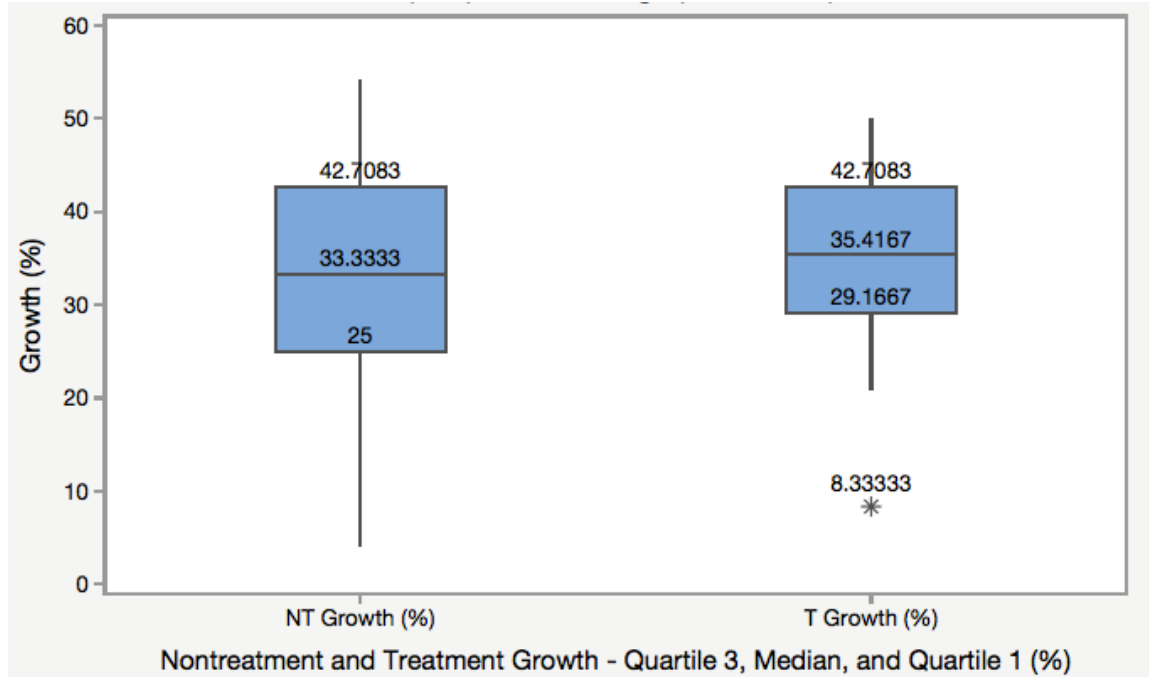


Figure 2. Results showing a comparison between non-treatment and treatment growth on content assessments for high-achieving students, (n=18).

Growth results from average performers (n=21) in the class showed an increase with the third quartile and the median for the treatment unit (Figure 3). The standard deviation tightened in the treatment results, and the mean increased by 8% suggesting that this group may have benefited from treatment.

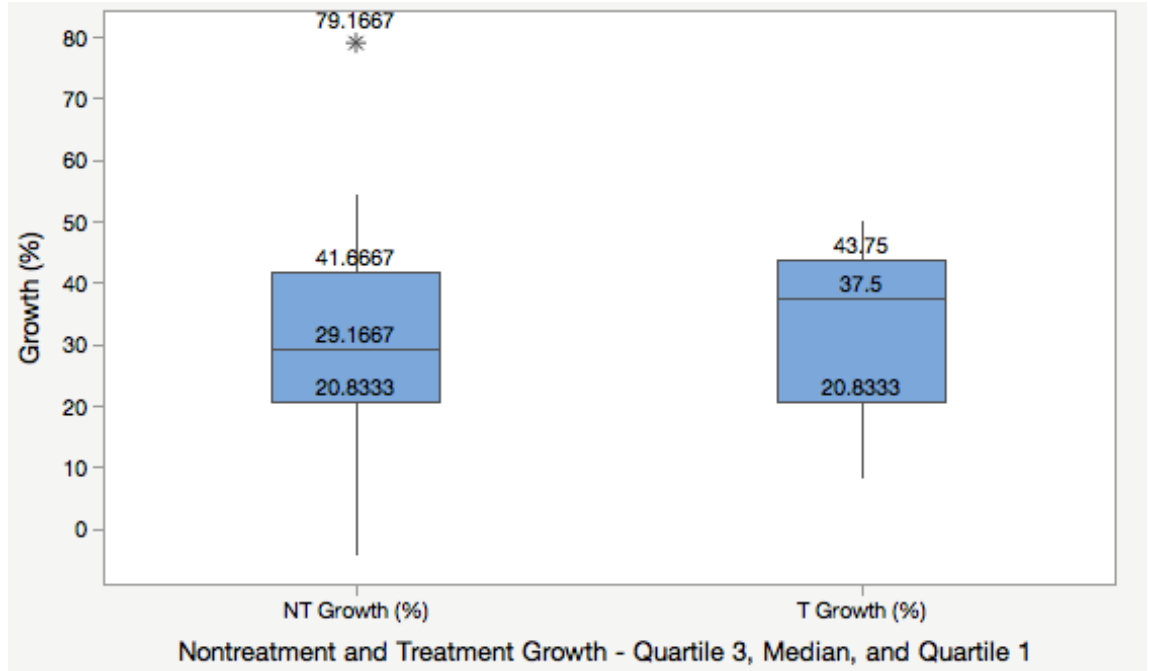


Figure 3. Results showing a comparison between non-treatment and treatment growth on content assessments for average-achieving students, (n=21).

Below average performers in the class (n=23) yielded a median that was 4% higher for the treatment unit, but quartiles 1 and 3 were the same between the units (Figure 4). The mean was 3% higher for the treatment unit, but the standard deviation increased in the treatment unit. Below average performers probably did not benefit from treatment according to these results alone.

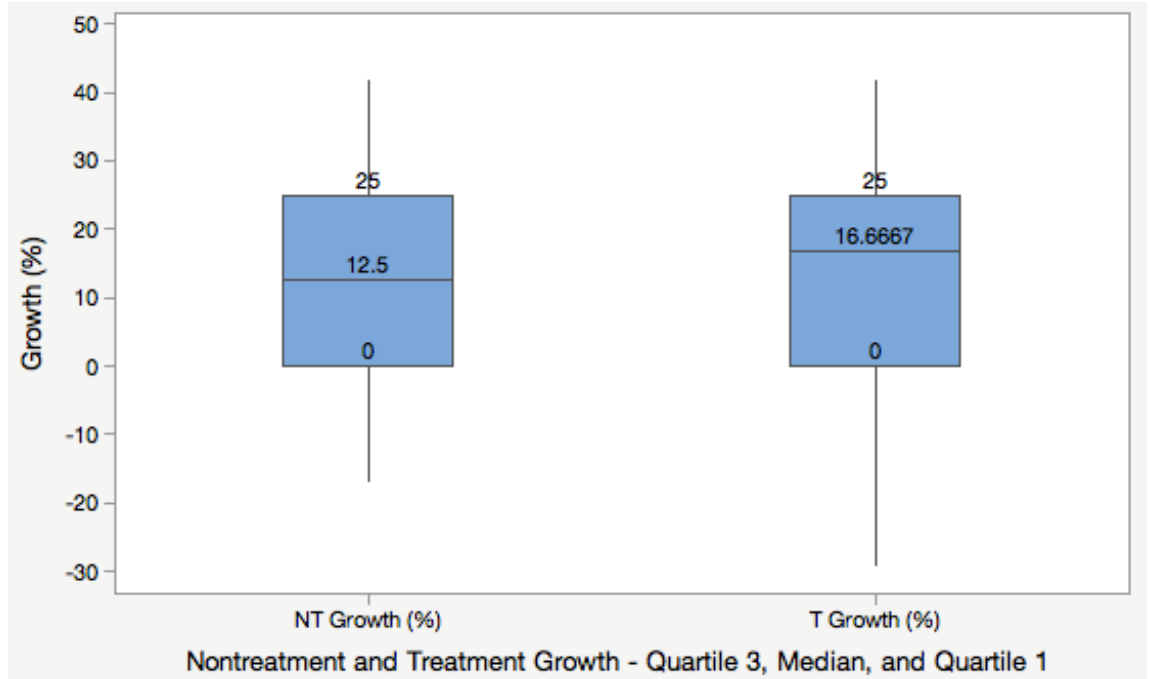


Figure 4. Results showing a comparison between non-treatment and treatment growth on content assessments for below average-achieving students, (n=23).

Students with IEPs and students with 504 Plans were also sorted. Out of nine students, six of them showed growth in the treatment unit (Figure 5). The median and quartile 3 were higher in the treatment unit. Results in quartile 1 were lower, and the standard deviation was higher in the treatment unit because two of the students who did not show growth received really low scores that skewed the data for this small group of students.

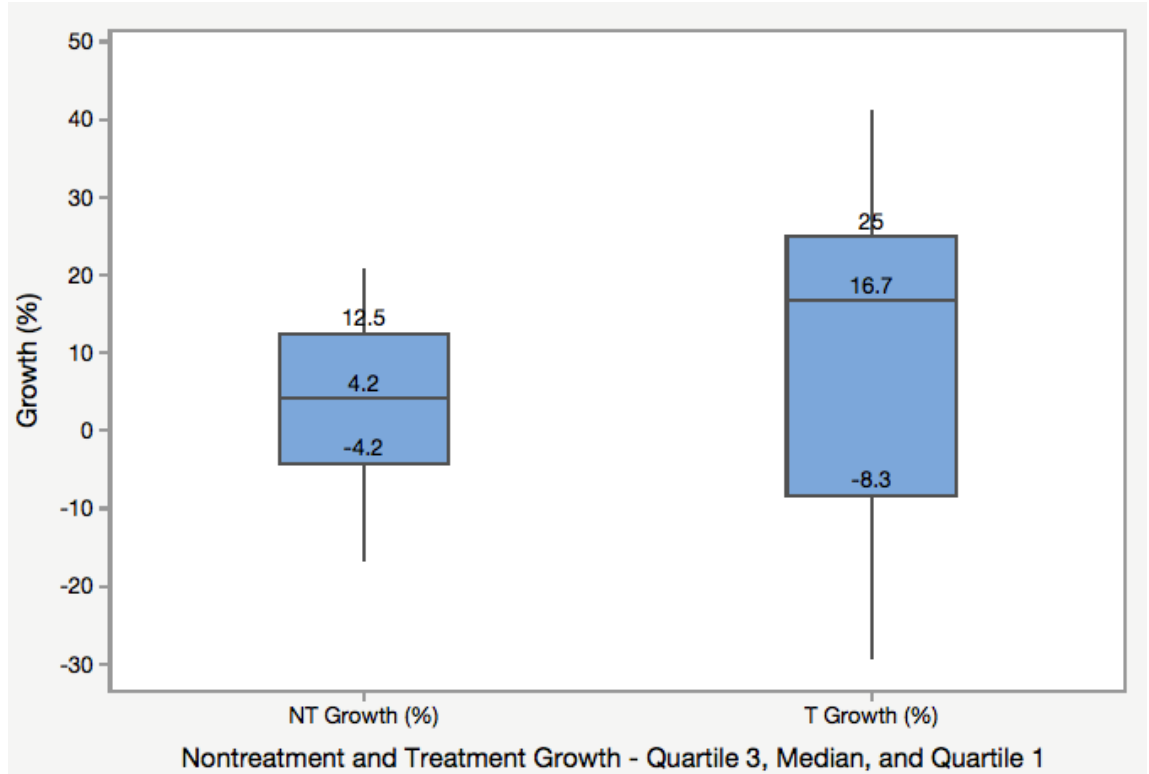


Figure 5. Results showing a comparison between non-treatment and treatment growth on content assessments for IEP and 504 students, (n=9).

Students were also sorted by gender. When comparing all males and females, the results for males revealed greater benefit from treatment (Figure 6). The median, average, and quartile 1, increased in the treatment results for males. The standard deviation decreased slightly in the treatment results for males. The median and quartile 3 increased in the treatment results for females. The average was about the same, quartile 1 decreased, and the standard deviation increased slightly in the treatment results for females.

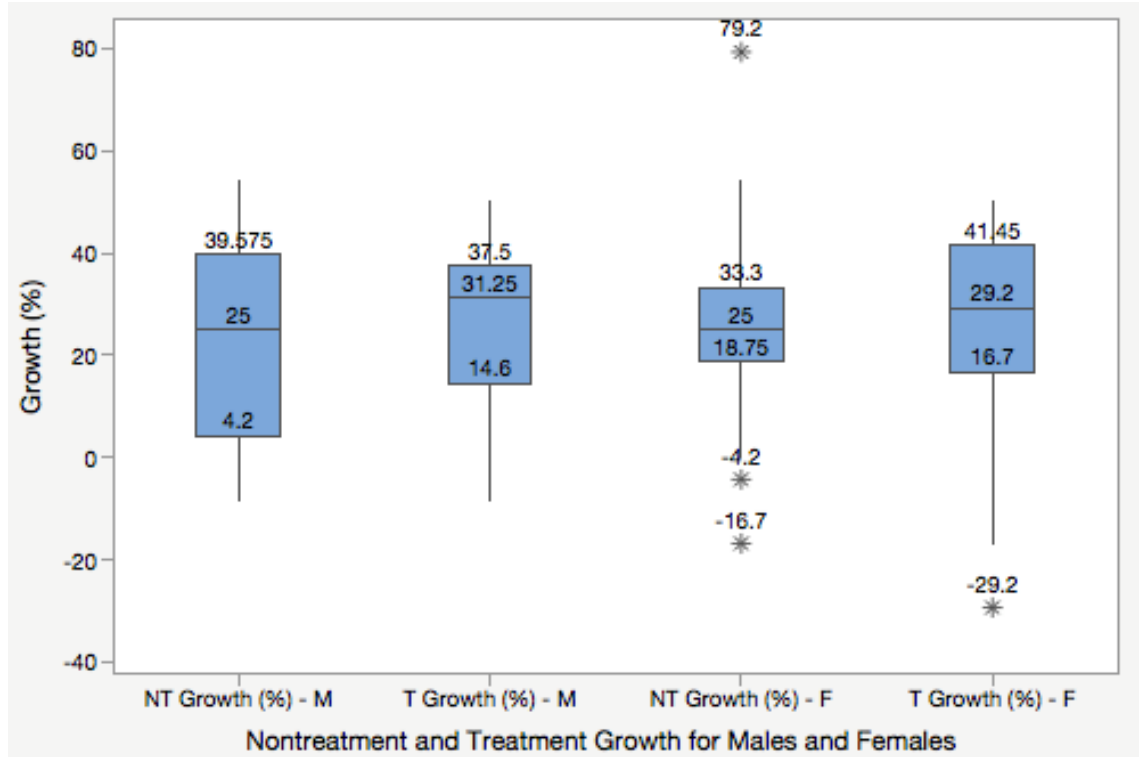


Figure 6. Results showing a comparison between non-treatment and treatment growth on content assessments by gender, (n=26 & 37 respectively).

Both groups were sorted into subgroups by achievement. Results for females are shown in Figure 7. Results for males are shown in Figure 8. In both scenarios, Group 1 refers to above average achievers, Group 2 refers to average achievers, and Group 3 refers to below average achievers. Note in Figure 7 that the females from Group 1 are absent.

There was no significant change between non-treatment and treatment performance from high-achieving females (Figure 7). More interesting were the results for females in Groups 2 and 3. Results for average-achieving females showed an increase in the average, median, quartile 1, and quartile 3 for the treatment unit. The standard deviation decreased slightly in the treatment unit. Results for below average-achieving females showed a decrease in the average, the median, and quartile 3 for the treatment unit.

These results also reveal an increase in the standard deviation for the treatment unit.

Treatment appeared to have worked for average-achieving females but not for below-average achieving females.

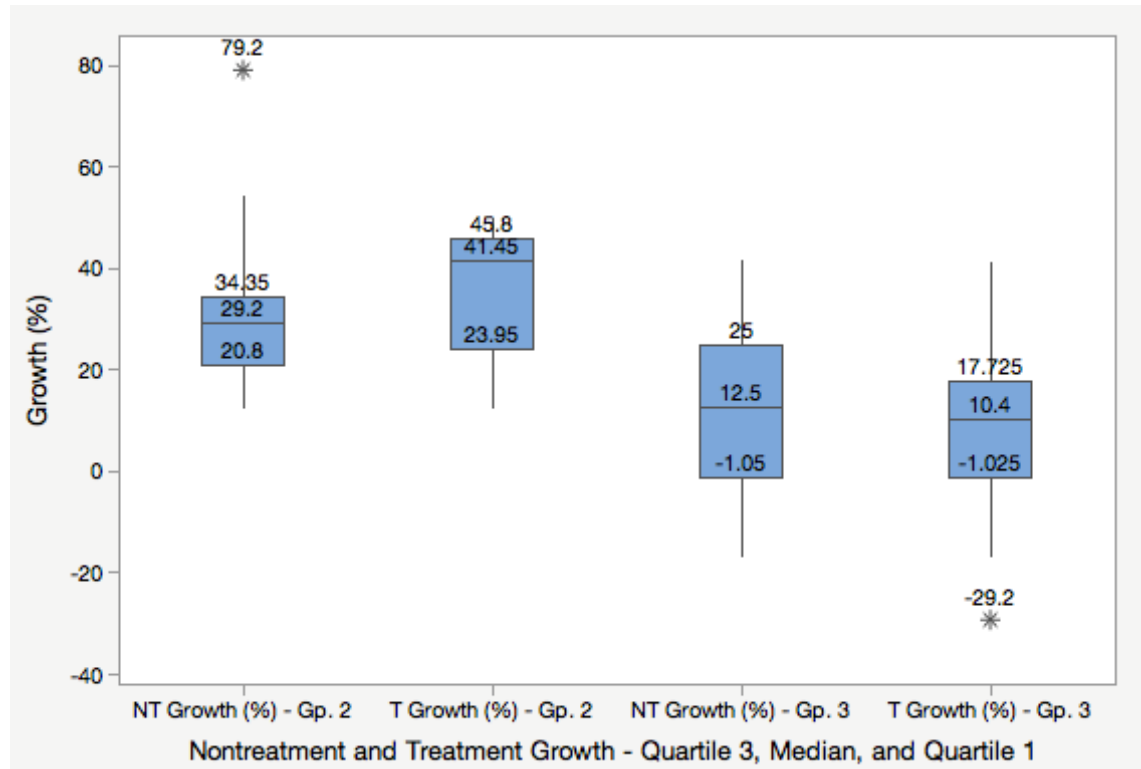


Figure 7. Results showing a comparison between non-treatment and treatment growth on content assessments by average-achieving females and below average-achieving females, (n=14 & 10 respectively).

Results for males show improvement for groups 1 and 3 in the treatment unit.

Group 2 results did not reveal significant improvement in the treatment unit (Figure 8).

The highest achievers performed the best with respect to median and quartiles. The lowest achievers revealed the lowest median. Results for above average-achieving males showed an increase in the average and quartile 1 for the treatment unit. The median and quartile 3 were the same. The standard deviation tightened in the treatment unit. Results for average-achieving males showed an increase in quartile 1 for the treatment unit. The average, median, and quartile 3 decreased in the treatment unit, and the standard

deviation was less in the treatment unit. The lowest achievers showed increases with everything, but this includes the standard deviation.

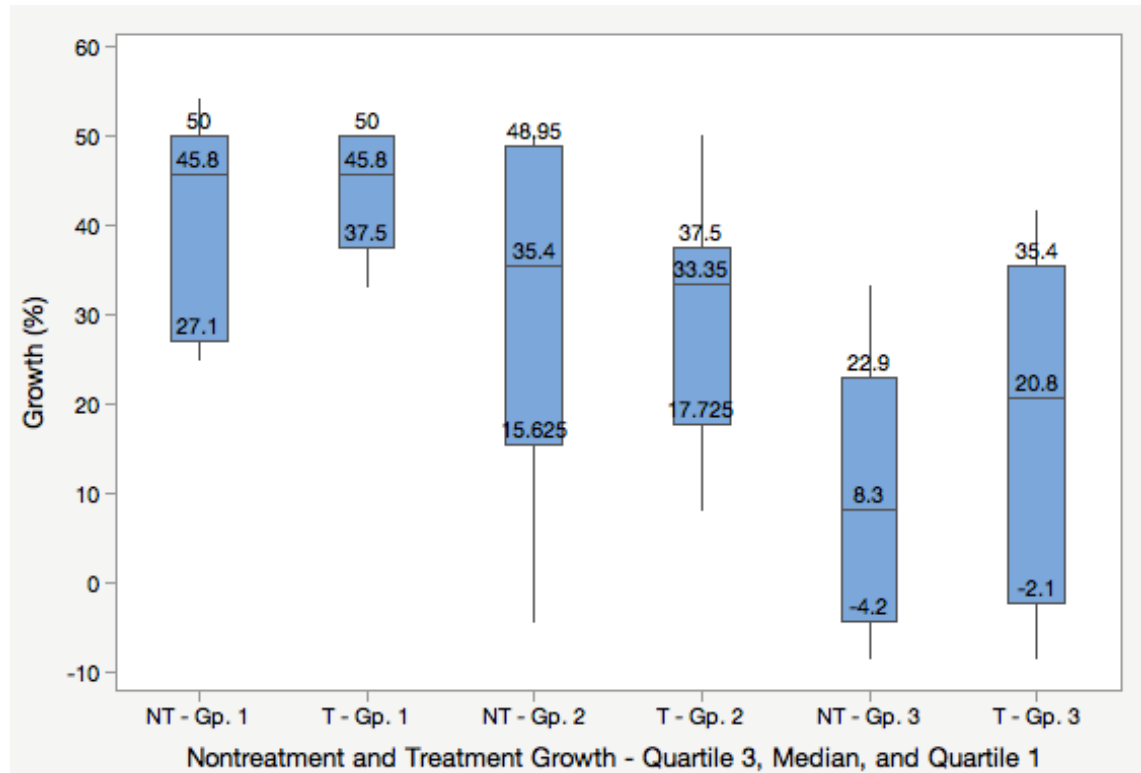


Figure 8. Results showing a comparison between non-treatment and treatment growth on content assessments by above average-achieving males, average-achieving males and below average-achieving males, (n=5, 8, & 13 respectively).

Post-unit interviews were given to a total of 30 students after non-treatment and treatment units. Students were sorted by ability once again (where Group 1 contained highest achievers and Group 3 contained lowest achievers). Within each group, five male students were interviewed and five female students were interviewed. Students were selected based on a first come, first served basis. Many students wanted to participate, so I had no problem filling each gender and academic ability group. Each interview lasted approximately seven to ten minutes. Interviews were recorded using Photo Booth's video function. The last five questions in both sets of interview questions led to

quantitative data because these questions addressed specific content so that students could demonstrate their understanding of what was taught in each unit (Table 3).

Table 3

Content-related Interview Questions for Post Non-treatment Unit

Question #	Question
9	Draw 4 horizontal layers of rock.
10	Label them from top down: A, B, C, and D.
11	Which of these layers is youngest, and how do you know?
12	You find a trilobite in layer C, and you find a bony fish fossil in layer B. How does this support the statement that B is younger than C?
13	How do faults and igneous intrusions help us to infer relative ages in rock outcrops?

All students in each group were able to follow instructions to sketch four layers of rock and properly label them (Table 4). All students from Group 1 were able to answer all of the content questions correctly. Most students in Group 2 were able to answer all of the content questions correctly. While most students from Group 3 were able to answer all of the first three content questions correctly, they did not perform as well as Group 2 did for the last two questions.

Table 4

Answers to Content-related Interview Questions for Post Non-treatment Unit

Question #	% Correct from Group 1 (high achievers)	% Correct from Group 2 (average achievers)	% Correct from Group 3 (low achievers)
9	100	100	100
10	100	100	100
11	100	100	100
12	100	70	50
13	100	80	60

The last five interview questions for the post-treatment unit are shown to compare the results to the post non-treatment unit results (Table 5).

Table 5

Content-related Interview Questions for Post-Treatment Unit

Question #	Question
9	If you wanted to find an absolute age for a fossil bone that was 15,000 years old, how would you do it?
10	Which radioactive isotope would you use?
11	Why would you choose that isotope?
12	How does that isotope give you an age?
13	Draw a general graph that shows the radioactive decay curve.

All students in Group 1 answered all questions correctly (Table 6). Most students in Group 2 answered all questions correctly. All students from Group 3 answered two of the questions correctly. Only 60% of these students answered questions 9 and 12 correctly while 70% of them answered question 13 correctly. This trend is consistent

with that shown in Figures 7 and 8: Highest achievers showed the highest results, lowest achievers showed the lowest results, and the average achievers were between the two groups.

Table 6

Answers to Content-related Interview Questions for Post-Treatment Unit

Question #	% Correct from Group 1 (high achievers)	% Correct from Group 2 (average achievers)	% Correct from Group 3 (low achievers)
9	100	80	60
10	100	100	100
11	100	100	100
12	100	70	60
13	100	80	70

These results do not show strong support that flipping the classroom allowed students to better comprehend the information delivered during treatment. The overall results from the interview content questions show a stronger response from students for the non-treatment unit. Since these questions involved the interpretation of charts, they also infer that students were not better at interpreting charts after the treatment unit.

Classroom Assessment Techniques (CATs) were used three times during the non-treatment unit and during the treatment unit. Each CAT included five questions and was given at the end of a lesson to check for understanding. Results are listed as the percent of students who answered all questions correctly, three out of five questions correctly, and less than three out of five questions correctly. CAT 1 was used to assess students' ability to interpret charts and graphs thus helping to answer my research sub-question about whether or not flipping the classroom helps students to better interpret charts and graphs.

Results from CAT 1 show that many students got more questions answered correctly for the treatment unit CAT (Tables 7 and 8). This supports the statement that flipping the classroom positively affects students' ability to interpret graphs and charts. CATs 2 and 3 were related to content. CAT 2 does not show favorable results for the treatment unit, as more students answered more questions correctly during the non-treatment unit. Results were fairly evenly distributed between treatment and non-treatment units for CAT 3. In addition to CAT 1, there were about 10 questions that contained charts or graphs for students to interpret on each pre- and post-unit assessment for the non-treatment and treatment units. An item analysis of the results showed a 16% increase in correct questions related to graphs and charts on the treatment unit.

Table 7
Results from CATs for Non-treatment Unit (n=63)

CAT # (all CATs contained 5 questions)	% of students answering all questions correctly	% of students answering 3/5 questions correctly	% of students answering less than 3/5 questions correctly
1	60	13	27
2	54	32	14
3	51	24	25
Average	55	23	22

Table 8
Results from CATs for Treatment Units (n=63)

CAT # (all CATs contained 5 questions)	% of students answering all questions correctly	% of students answering 3/5 questions correctly	% of students answering less than 3/5 questions correctly
1	57	38	5
2	44	30	26
3	56	22	22
Average	52	30	18

When sorted by ability groups, high- achievers performed just as well on non-treatment CATs as they did with the treatment CATs. Average-achievers performed slightly worse on the treatment CATs than on the non-treatment CATs. Below-average achievers performed better on treatment CATs than on the non-treatment CATs.

Student surveys were given after the post-unit assessment for treatment and non-treatment units. Since the survey was voluntary, not all students completed it (but most did). The survey questions from the post non-treatment unit are included with results lumped into three categories: number of students who disagreed, number of students who were indifferent, and number of students who agreed (Table 9). Results show that three questions contain answers that were split almost evenly in the “agree” and “disagree” categories. Students appeared to be split on their feelings about their abilities to practice science concepts at home alone. Students were evenly split about their perceptions of their attentiveness in class. Finally, students were evenly split in their responses to whether or not they use their notes to prepare for exams. Regarding student feelings about classroom lectures, most students claimed to benefit and preferred in-house lectures. Most did not feel stupid asking questions, and most liked to have their questions answered straight away. Most did not think that the teacher lectures too fast, and many did feel that they needed the teacher to understand Earth science concepts. Regarding student perceptions about graphs, most students felt that graphs helped them to understand data, and many stated that they did not have trouble interpreting new graphs.

Table 9
Survey Questions for Post Non-treatment Unit with Results (n=54)

Ques. #	Question	# of Students Who Disagree	# of Indifferent Students	# of Students Who Agree
1	I find it easy to practice science concepts at home by myself.	17	17	20
2	I like it when the teacher delivers notes in class.	8	14	32
3	I benefit from class discussion during teacher lectures in class.	9	16	29
4	I usually “zone out” when the teacher lectures in class.	24	10	20
5	My homework answers are usually correct.	6	14	34
6	The teacher lectures too fast for me to absorb information in class.	40	8	6
7	I like having the lectures so that I can ask questions right away.	14	15	25
8	I don’t need teacher lectures to understand Earth science concepts.	27	18	7
9	I re-read my science notes to prepare for exams.	18	19	17
10	I feel stupid asking questions in class if I don’t understand.	28	13	13
11	Interpreting new graphs is difficult.	27	13	14
12	Graphs help me to understand data.	7	17	30

Survey questions from the post treatment unit are included with results lumped into three categories: number of students who disagreed, number of students who were

indifferent, and number of students who agreed (Table 10). Survey results revealed five questions that contained answers that were split nearly evenly in the “agree” and “disagree” categories. Students appeared to be split on their feelings about their abilities to practice science concepts at home alone, and this was consistent with the non-treatment survey results. Students were evenly split in their responses to whether or not they used their notes to prepare for exams, and this was consistent with the non-treatment survey results. Students were split with their responses to multi-tasking during teacher videos and their feelings about the nature of the notes that they used for quizzes. Finally, students were split with their feelings about their abilities to interpret new graphs. The latter is slightly inconsistent with non-treatment survey results in that more students felt they could interpret new graphs after the non-treatment unit. Many students did not like watching the videos at home, and many claimed to miss the teacher lectures. Most students paused the videos while watching, and most claimed to like having that option. Many students felt that they needed the teacher to understand Earth science concepts, and this was consistent with non-treatment survey answers. Most students liked having the extra time in class to practice concepts, and most felt as though that helped them to understand Earth science concepts.

Table 10
Survey Questions for Post Treatment Unit with Results (n=51)

Ques. #	Question	# of Students Who Disagree	# of Indifferent Students	# of Students Who Agree
1	I find it easy to practice science concepts at home by myself.	21	13	17
2	I like watching the teacher videos at home.	25	10	16
3	I miss class discussion during teacher lectures in class.	14	8	29
4	I multi-task during teacher videos at home.	17	10	24
5	My homework notes are thorough, and I get good grades on them.	15	17	15
6	I pause the video when taking notes from the teacher videos.	11	8	32
7	I like having the option to pause teacher videos.	8	11	32
8	I don't need teacher lectures to understand Earth science concepts.	29	11	12
9	I re-read my science notes to prepare for exams.	11	19	21
10	I like having time in class to practice concepts.	0	11	40
11	Interpreting new graphs is difficult.	17	22	12
12	Graphs help me to understand data.	4	21	26
13	Having more time to practice in class is making science easier for me.	5	13	33

Non-content related interview questions given after the non-treatment and treatment units aided in the interpretation of the conclusions drawn about student attitudes from this action research (Appendix M). Results are summarized and broken into responses by ability groups (Appendix N). Interpretation of this qualitative data appears in the next section of the paper.

Data was collected to correlate homework completion to quiz results for the treatment unit. The results were very clear and need not be displayed graphically. Students who watched the videos and completed the guided questions did very well on the open-note quizzes. Students who did not watch videos and/or did not complete the guided questions did not do well on their open-note quizzes. Another trend revealed that students with a history of not completing their homework either did not watch any videos at all or they only watched limited portions of some.

To discover the effects of flipping the classroom on teachers' attitudes, a regular journal was kept throughout the non-treatment and treatment units. Entries were created daily and often were completed at the end of the day. These entries were sometimes based on quick reminders written on Post-It Notes of thoughts and reactions that happened during the day as implementation of lessons was occurring. Initially, pre-determined prompts and questions were included in the journal, but they felt restrictive and made the task too laborious (to the point that the entries were not being completed). Consequently, a shift was made to a more free-flowing and perhaps emotional response to specific tasks that needed to be completed during the treatment unit. Generally speaking, there were no negative entries made during the non-treatment unit, as the methods utilized by the teacher

were familiar and comfortable. Nearly 80% of the entries made during the treatment unit were negative. All of the positive entries made during the treatment unit were the result of positive interactions with students during practice sessions in some of the classes. One class stood out as being the recipient of most of the teacher's negative journal entries during treatment. In this class, 77% of the students regularly did not complete homework. Some negative comments were a result of the teacher-loaded approach to flipping the classroom. Explanations for these comments appear in the next section of the paper.

A record was kept to record the number of hours necessary to prepare for the non-treatment unit versus the treatment unit. The treatment unit took two more hours to prepare for compared to the non-treatment unit. This does not include the time needed to burn DVDs for the 17 students who did not have access to the Internet at home. Bolivar-Richburg Central School District has a "no portable thumb-drive" policy, thus the teacher was not allowed to simply purchase and sign-out flash drives to students. The technology problems associated with flipping the classroom in a rural district led to negative journal entries in some cases.

Three colleagues in the building either had experience with flipping the classroom or had been actively flipping their classrooms for at least a year within Bolivar-Richburg Central School District. Conversing with two of them regularly allowed for a collection of perceptions by other teachers about their attitudes with flipping the classroom. The only negative feelings that these teachers had about flipping involved the technological limitations of the district and toward those students who regularly did not have homework.

All other comments were positive, and both teachers felt that flipping the classroom was worth continuing with classes where most students regularly completed their homework.

INTERPRETATION AND CONCLUSIONS

Some results of this action research showed that flipping the classroom did have a positive impact on some students' understanding of Earth and space science concepts, on their interpretation of graphs and charts, and on their attitudes about how they learn. My primary action research question was directed at the effects of using a Flipped Classroom with a high school Earth science class. The question was intentionally vague to help minimize outcomes that were anticipated and to assist in keeping an open mind to potential emerging trends. Results from this action research suggested that flipping the classroom works for some students, but not for everyone. When grouped together, evidence from the growth on the post-unit assessments for the non-treatment and treatment units revealed that a flipped classroom did not yield fantastic results for everyone. Trends emerged as students were sorted by ability, gender, and both. Groups that benefited the most were students identified with learning disabilities, average-achieving females, above average-achieving males, and below average-achieving males.

The specific sub-question about the effects of students' understanding of Earth science concepts and students' ability to interpret tables and graphs was answered by considering data from the growth between pre- and post-unit assessments for non-treatment and treatment units, data from CATs, and content-related answers from interviews. Comparison of growth between non-treatment and treatment units revealed that students with learning disabilities who had Individualized Educational Plans (IEPs)

benefited from treatment. CAT data supports this claim for all but one of the IEP students. This student's CAT results showed no change. I believe this is because the student has little short-term memory. Everything is difficult for him to remember even though he tries so hard. Content specific questions during interviews also revealed that students with IEPs performed better with treatment. These students were especially good at elaborating when given prompts. When asked why the treatment unit yielded better results for him, one student told me "I like that I can pause videos and watch them over and over if I need to" while another stated "Practicing in class with you and Miss Kirnan makes it easier to remember stuff." Some IEP students revealed that it is hard for them to keep up with teacher lectures and going at their own pace with the videos made it easier.

Below-average achieving males yielded a similar result to students with IEPs on their treatment growth, CATs, and content-related interview questions for similar reasons. Above average-achieving males and above-average achieving females performed better on post-unit assessments for treatment, but they performed equally well on CATs and content-related interview questions. When asked why they thought this was true, six above-average achievers revealed that they were always going to do the work even if they didn't like the method. An above-average female stated "I already knew what I was doing, so the practice in class just made it easier for me to remember how to do things on the test. I didn't have to study as much before the test."

Why didn't the below-average females gain from the treatment if their male counterparts did? Homework completion was minimal in both groups, but I did make

these students watch the videos while the rest of us were completing practice problems. Since all of this happened before the post-assessment, students got the information but had less time for practice in class. I do not have an answer for this after giving it considerable thought aside from some speculation about the difference in confidence levels. Furthermore (and also speculative), 50% of the below-average achieving females have made multiple trips to the guidance counselor this school year to work through personal problems and related high school drama.

Why didn't the average males show the gains that average-achieving females did? There appears to be a maturity gap between males and females in the ninth grade. The males are more distracted by each other than the females are. I logged the amount of times that I noticed specific students were off-task. It turns out that the average-achieving males were off-task more often than any other group during practice in class during treatment and during traditional teaching methods during non-treatment.

To answer the sub-question about the effects of flipping the classroom on students' attitudes in science class, data collected during interviews, from surveys, and from teacher observations were recorded in a journal. Survey results (Tables 9 & 10) revealed that most students missed classroom lectures and did not like watching the videos. Interviews revealed that many students didn't like my teaching style in videos. For example, one student revealed, "your voice is monotone on the videos and you aren't like that in class." Proponents of the Flipped Classroom warned against a monotone voice in videos. Bergmann and Sams suggested that teachers animate their voices and change inflection to keep it exciting (Bergmann & Sams, 2012). Many students felt that

they did need the teacher to understand the concepts. I considered this advice when creating the videos but ran out of time during the editing process. In time, perhaps the quality of these videos would improve with practice.

Several students (from all ability groups) revealed in the interview that they really liked having their questions answered right away rather than writing them down and receiving an answer when they got to class. Most students felt that the teacher did not move too quickly through the notes. The reason for this is probably because I write the notes with the students for every class, every year. I do this to keep myself from going too fast. I often given examples after each new concept is introduced, and that sometimes involves props. That is harder to achieve in the videos that I created through Camtasia software. There were a lot of complaints about the volume level of the videos. I had recorded complaints from 16 of the 63 students after the first video. I learned from my mistake and spoke louder into the microphone for subsequent videos. It was not all bad, as surveys and interviews showed that students felt that they really benefited from the practice time in class. There were a handful of students (especially those with IEPs) that liked to watch the videos so that they could move more slowly through the material.

To attempt to measure the effects of flipping the classroom on the teacher, a teacher journal was kept, informal discussions were had with teachers who were experienced in flipping their classrooms, and a preparation time log was kept. Creating effective videos, video sheets, video quizzes, and follow-up practice materials was much more time-consuming than methods employed during non-treatment. Problems with technology and district policies further hindered the efficiency process. Having so many

students (27%) with no Internet access at home compounded the problem, as I had to burn DVDs for each student for each lesson. Most of my frustration came from the group of students who just never did their homework. Most of the students from this group watched the first video out of kindness for me, but they did not have the discipline to follow through with subsequent videos. Their only access to material was what the teacher presented in class. Flipping the classroom with them was very discouraging. My mathematics colleague who shared this group of students with me became so disenchanted with this group, that she stopped using videos with them and reverted to traditional methods. She continued flipping her classroom for other students because she was yielding such great results. She, too, was frustrated by district policies and the inefficiencies of getting the flipped classroom started, but her spirits lifted after getting all of the videos created and reaping the good results from the students. One of my social studies colleagues flips his classroom with juniors. His videos are so professional and interesting that Bergmann and Sams contacted him to complete an interview to acquire data for their next book. He feels that he has fewer problems with students not completing homework (though he reveals he does have a group who do not complete their homework) because the students are more mature by the time they get to his classroom.

Further Questions

Using three videos to draw solid conclusions about the effectiveness of a flipped classroom is simply not enough data to support results. A valid question to ask is how credible are these initial results? Continuing this action research with more videos is an

obvious next step. Bergmann and Sam (2012) recommend that teachers who feel that building exciting videos is not their strength could use effective videos from other teachers if those videos exist. Would more of my students show gains if given the opportunity to watch guest speakers for homework and then practice with me in class? I do know New York State teachers who have wonderful videos that they do not mind sharing with others. This could be a next step for me and for my students. Bergmann and Sam (2012) also agree that creating the videos together in a conversational manner was much more natural to them, and the students enjoyed the dialogue. I am the only Earth science teacher, but I could see making a few videos with the biology teacher to better link our common themes, like evolution, for example.

Given the low economic status of many people in the community where I teach, one wonders how much poverty plays a role in student success? The “achievement gap” is no secret in this country. I almost went down this path to determine if our data concurs that economic status is one reason why some of my students are not doing their homework, but it feels like an invasion of privacy. There also might be issues with legality of knowing who, specifically, receives a free or reduced lunch. Knowing why some of my students are not doing their homework is a worthy cause, for there may be ways to solve it with some persistence on my part.

VALUE

The results of this action research have made me a more thoughtful planner and a more reflective teacher. Many educators know how important reflection is, but rarely do public school teachers have time during the day to reflect. I have become better at

training my brain to reflect within shorter time frames, and I have developed quick methods (like writing on a Post-It) to remind myself about events that require reflection. Using Classroom Assessment Techniques has become a valuable part of my weekly routine. I have become very efficient at sifting through these CATs and re-teaching as needed. They also serve as good review for my students. My students quite enjoy them, for they know that they count toward their participation and that this helps their overall grade. Many of them are now invested in carefully answering the CATs, and I have been pleasantly surprised by this observation. Survey results that revealed that students miss my classroom lectures were very flattering. I did not realize how much of a positive rapport I had built with students until I read those surveys and conducted those interviews. I also was not expecting so many students to be interested in the research. Many of them wanted to interview with me, and I conducted interviews with 50% of my population. Some of them claimed that they liked being part of my endeavor to improve my effectiveness (though they did not state it that way).

Other teachers have expressed interest with those of us who are flipping our classrooms. This has increased collaboration in a school district where too little collaboration occurs. Members of the technology department are willing to take the anti-flash drive policy to the school board to see if we can change it and allow read only flash/thumb drives for students who do not have access to the Internet at home. Time will tell if that suggestion will come to fruition.

Before the 2015-2016 school year begins, I plan to find interesting videos from other teachers in the state who are flipping their Earth and space science classrooms. I

will obtain permission to use their videos in my classroom. Collecting data using other teachers' videos is my next step with analyzing the effectiveness of flipping the classroom on student's ability to understand Earth and space science concepts. If the results are positive, I will move toward the Flipped-Mastery Classroom as outlined by Bergman and Sams (2012). I will continue to use CATs as review and to assess student understanding so that I know who is struggling and that I might re-teach as necessary. If I find the Flipped-Master Classroom to be good for my students, then I will consider presenting my findings at the 2016 annual meeting for New York State science teachers in Rochester, NY. More thoughtful and careful studies are needed, as (Goodwin & Miller, 2013) there is not enough peer-reviewed literature and scientific evidence to indicate how well flipped classrooms are working for students and teachers, but more action research data emerges everyday.

Goodwin and Miller (2013) share:

The lack of hard scientific evidence doesn't mean teachers should not flip their classrooms; indeed, if we only implemented strategies supported by decades of research, we'd never try anything new. Until researchers are able to provide reliable data, perhaps the best we can do is to ask, Do the purported benefits of flipped classrooms reflect research-based principles of effective teaching and learning (p. 80)?

REFERENCES CITED

- Angelo, T. & Cross, K. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers* (2nd ed.). San Francisco: Jossey-Bass.
- Ash, K. (2012). Educators view 'flipped' model with a more critical eye. *Education Week*, 32(2), S6-S7.
- Bergmann, J. & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day*. International Society for Technology in Education: Courtney Burkholder.
- Bergmann, J. & Sams, A. (2014). Flipping for mastery. *Educational Leadership*, 71(4), 24-29.
- Bloom, B.S. & Ward, C.F. (1952). The Chicago Bachelor of Arts degree. *The Journal of Higher Education*, 23(9), 459-467.
- Dill, E. M. (2012). *The impact of flip teaching on student homework completion, behavior, engagement, and proficiency*. Completed to meet the requirements of University of New England MS Ed. Program. Retrieved from <http://www.lessonpaths.com/learn/i/flipped-classroom-research-paper/17-flipped-research-paper-action-research-effects-of-flipped-classroom>
- Educational Broadcasting Corporation (EBC), (2004). *Concept to Classroom*. Retrieved from: <http://thirteen.org/edonline/concept2class/constructivism/>
- Goodwin, B. & Miller, K. (2013). Evidence on flipped classrooms is still coming in. *Educational Leadership*, 70(6), 78-80.
- Khan Academy, (2015). Retrieved from: <https://www.khanacademy.org/>.
- Lasry, N, Mazur, E., & Watkins, J. (2008). Peer instruction: From Harvard to the two-year college. *American Journal of Physics*, 76(11), 1066-1069.
- Meyer, R. (2013, Sept. 13). The post-lecture classroom. How will students fare? *The Atlantic*. Retrieved from: <http://www.theatlantic.com/technology/archive/2013/09/the-post-lecture-classroom-how-will-students-fare/279663/>
- Staker, H., & M. B. Horn (2012). Classifying K-12 blended learning. *Innosight Institute*, 3.
- Tairab, H. H. & A. K. Khalaf Al-Naqbi. (2004). How do secondary school science students interpret and construct scientific graphs? *Journal of Biological Education*, 38(3), 127-132.

APPENDICES

APPENDIX A

PRE AND POST ASSESSMENT FOR TREATMENT UNIT

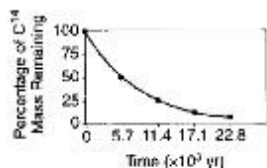
Pretest and Posttest for Absolute Dating Unit

Name: _____

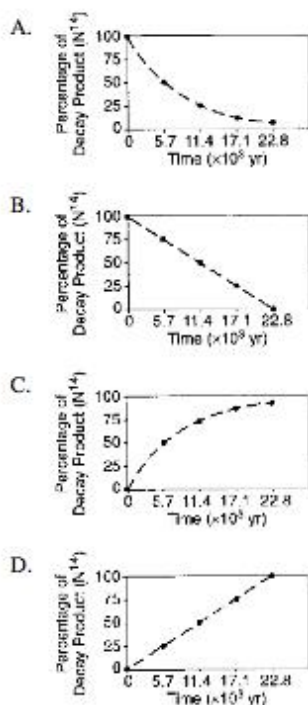
Date: _____

1. Using radioactive dating methods and mathematical inferences, scientists have estimated the date of Earth's formation to be approximately
 - A. 1.1×10^6 years ago
 - B. 2.4×10^6 years ago
 - C. 3.3×10^9 years ago
 - D. 4.6×10^9 years ago
2. Radioactive carbon-14 dating has determined that a fossil is $5.7 \times (10^3)$ years old. What is the total amount of the original (C^{14}) still present in the fossil?
 - A. 0% B. 25% C. 50% D. 74%
3. A comparison of the age of Earth obtained from radioactive dating and the age of the universe based on galactic Doppler shifts suggests that
 - A. Earth is about the same age as the universe
 - B. the universe is much younger than Earth
 - C. the solar system and Earth formed billions of years after the universe began
 - D. the two dating methods contradict one another
4. Which statement best explains why geologic materials from the Quaternary Period must be dated by using radioactive isotopes different from the isotopes used to date materials from the Cambrian Period?
 - A. All rocks contain radioactive substances
 - B. Some isotopes decay faster than others
 - C. Not all isotopes form stable decay products
 - D. The decay of atoms occurs as a random event

5. A graph of the radioactive decay of carbon-14 is shown.



Which graph correctly shows the accumulation of nitrogen-14, the decay product of carbon-14, over the same period?



6. Which two elements are most useful for the radioactive dating of recent organic remains?

- A. C^{14} and N^{14} B. K^{40} and Ca^{40}
C. U^{238} and Pb^{206} D. Rb^{87} and Sr^{87}

7. The half-life of a radioactive substance is mainly controlled by the

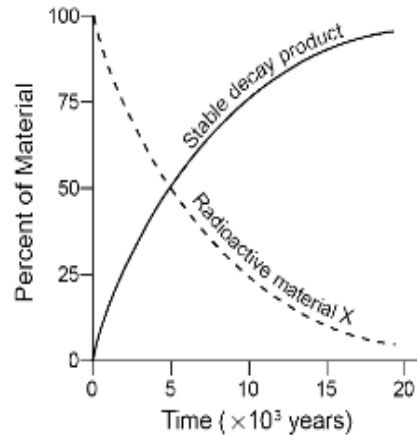
- A. amount of the substance
B. composition of the substance
C. pressure acting on the substance
D. temperature of the substance

8. Which process could be indicated by the expression below?



- A. crystallization of minerals in basalt
B. chemical weathering of marble
C. radioactive decay in granite
D. ozone depletion in the atmosphere

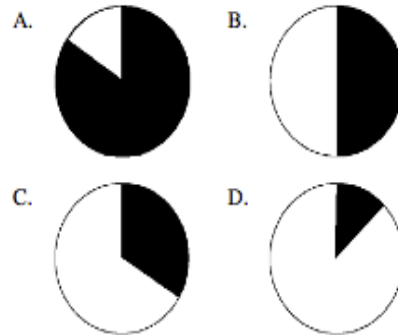
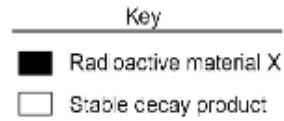
9. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, the graph below, and your knowledge of Earth science. The graph represents the decay of radioactive material X into a stable decay product.



What is the approximate half-life of radioactive material X?

- A. 5,000 yr B. 10,000 yr
C. 50,000 yr D. 100,000 yr

10. Which graph best represents the relative percentages of radioactive material X and its stable decay product after 15,000 years?



11. Each of the objects below has different amounts remaining of the original radioactive material X. Which object is most likely the oldest?



Rock
10% of the
radioactive
material
remains



Wood
33% of the
radioactive
material
remains



Shell
41% of the
radioactive
material
remains



Bone
52% of the
radioactive
material
remains

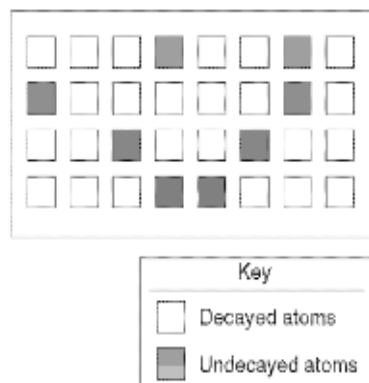
12. A bone sample contains only $\frac{1}{4}$ of its original radioactive C^{14} content. How old is the bone sample?

A. 1 C^{14} half-life B. 2 C^{14} half-lives
C. 9 C^{14} half-lives D. 4 C^{14} half-lives

13. Why are radioactive substances useful for measuring geologic time?

A. The ratio of decay products to radioactive substances remains constant in rocks.
B. The half-lives of radioactive substances are short.
C. Samples of radioactive substances are easy to collect from rocks.
D. Radioactive substances undergo decay at a predictable rate.

14. The accompanying diagram represents the present number of decayed and undecayed atoms in a sample that was originally 100% radioactive material.



If the half-life of the radioactive material is 1,000 years, what is the age of the sample represented by the diagram?

- A. 1,000 yr B. 2,000 yr
C. 3,000 yr D. 4,000 yr
15. The table below gives information about the radioactive decay of carbon-14. Part of the table has been deliberately left blank for student use.

Half-life	Mass of Original Carbon-14 Remaining (grams)	Number of Years
0	1	0
1	$\frac{1}{2}$	5,700
2	$\frac{1}{4}$	11,400
3	$\frac{1}{8}$	17,100
4	$\frac{1}{16}$	
5		
6		
7		

After how many years will $\frac{1}{128}$ gram of the original carbon-14 remain?

- A. 22,800 yr B. 28,500 yr
C. 34,200 yr D. 39,900 yr

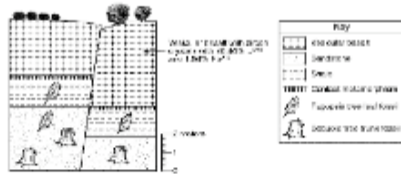
16. The characteristic of the radioactive isotope uranium-238 that makes this isotope useful for accurately dating the age of a rock is the isotope's

- A. organic origin
B. constant half-life
C. common occurrence in sediments
D. resistance to weathering and erosion

17. Uranium-238 that crystallized at the same time Earth formed has undergone approximately how many half-lives of radioactive decay?

- A. one half-life B. two half-lives
C. three half-lives D. four half-lives

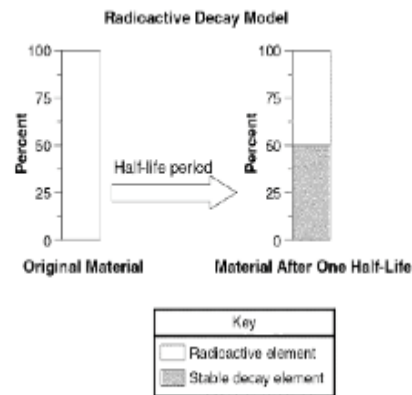
18. Base your answer(s) to the following question(s) on the geologic cross section provided, which represents an outcrop of various types of bedrock and bedrock features in Colorado.



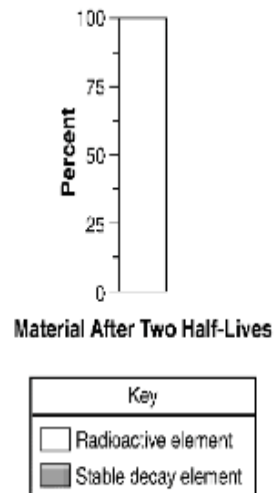
The vesicular basalt includes zircon crystals containing the radioactive isotope U-235, which disintegrates to the stable isotope Pb-207. The zircon crystals have 98.44% of the original U-235 remaining, and 1.56% has decayed to Pb-207. Based on the table below, how many half-lives have elapsed since the formation of these crystals?

Percent of U-235 Remaining	Percent Decayed to Pb-207	Half-Lives Elapsed
99.22	0.78	$\frac{1}{32}$
98.44	1.56	$\frac{1}{16}$
96.88	3.12	$\frac{1}{8}$
93.75	6.25	$\frac{1}{4}$
87.50	12.5	$\frac{1}{2}$
75.0	25.0	$\frac{1}{1}$
50.0	50.0	1
37.5	62.5	$1\frac{1}{2}$
25.0	75.0	2
12.5	87.5	3
6.25	93.75	4

19. Base your answer(s) to the following question(s) on the diagram below, which represents a model of the radioactive decay of a particular element. The diagram shows the decay of a radioactive element () into the stable decay element () after one half-life period.



On the diagram provided, shade in the amount of stable decay element present after the second half-life period.



20. Base your answer(s) to the following question(s) on the passage below and on your knowledge of Earth science.

Radiocarbon Dating

Radioactive carbon-14 (C^{14}), because of its short half-life, is used for the absolute dating of organic remains that are less than 70,000 years old.

Carbon-14 is an isotope of carbon that is produced in Earth's upper atmosphere. High-energy cosmic rays from the Sun hit nitrogen-14 (N^{14}), producing radioactive N^{14} . This N^{14} is unstable and will eventually change back into N^{14} through the process of radioactive decay. The proportions of N^{14} and ordinary N^{12} in Earth's atmosphere remain approximately constant.

Radioactive N^{14} , just like ordinary N^{12} , can combine with oxygen to make carbon dioxide. Plants use CO_2 during photosynthesis. The proportion of C^{14} to C^{12} in the cells and tissues of living plants is the same as the proportion of C^{14} to C^{12} in the atmosphere. After plants die, no new C^{14} is taken in because there is no more photosynthesis. Meanwhile, the C^{14} in the dead plant keeps changing back to N^{14} , so there is less and less C^{14} . The longer the plant has been dead, the less C^{14} is found in the plant. The age of organic remains can be found by comparing how much C^{14} is still in the organic remains to how much C^{14} is in a living organism.

Radioactive C^{14} was used to determine the geologic age of old wood preserved in a glacier. The amount of C^{14} in the old wood is half the normal amount of C^{14} currently found in the wood of living trees. What is the geologic age of the old wood?

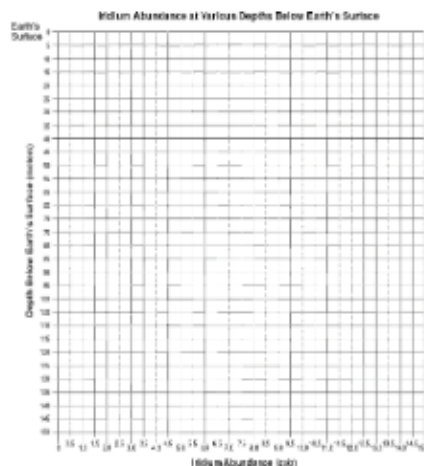
21. State *one* difference between dating with the radioactive isotope C^{14} and dating with the radioactive isotope uranium-238 (U^{238}).

22. Base your answer(s) to the following question(s) on the data table below and on your knowledge of Earth science. Iridium is an element rarely found in Earth's lithosphere but commonly found in asteroids. The data table shows the abundance of iridium, in parts per billion (ppb), found in a rock core sample taken in Carlsbad, New Mexico.

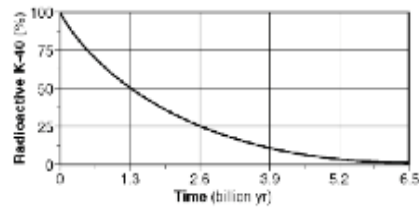
Iridium Abundance in a Rock Core Sample

Depth Below Earth's Surface (m)	Iridium Abundance (ppb)
0	0
50	0
100	0.5
105	0.5
113	0.5
115	13.5
119	0.5
120	0.25
128	0.25
135	0

On the grid below, construct a line graph of iridium abundance at various depths. Place an **X** to show the iridium abundance at *each* depth shown on the data table. Connect the **Xs** with a line.

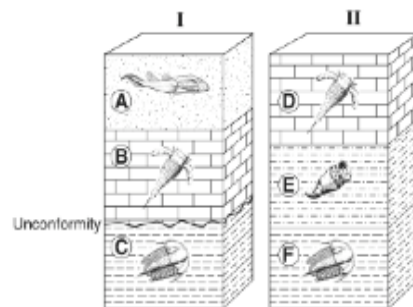


23. The graph below shows the rate of decay of the radioactive isotope K-40 into the decay products Ar-40 and Ca-40.



Analysis of a basalt rock sample shows that 25% of its radioactive K-40 remained undecayed. How old is the basalt?

- A. 1.3 billion years B. 2.6 billion years
C. 3.9 billion years D. 4.6 billion years
24. Base your answer(s) to the following question(s) on the diagrams below, which represent two bedrock outcrops, I and II, found several kilometers apart in New York State. Rock layers are lettered A through F. Drawings represent specific index fossils.



Explain why carbon-14 can *not* be used to find the geologic age of these index fossils.

25. The diagram below represents a sample of rubidium-87 (^{87}Rb).



Which diagram represents the correct proportion of ^{87}Rb to its decay product, ^{87}Sr , after two half-lives?

- A. B.
- C. D.

APPENDIX B

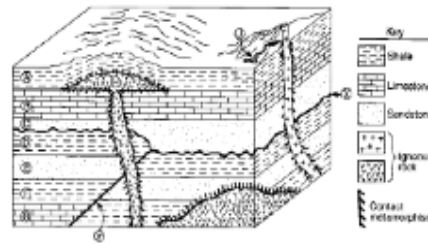
PRE AND POST ASSESSMENT FOR NON-TREATMENT UNIT

Pre test and Post test for Relative Age Dating and The Geologic Time Scale

Name: _____

1. What is the age of most of the surface bedrock found in New York State at a latitude of 45° ?
 - A. Precambrian Middle Proterozoic
 - B. Triassic and Jurassic
 - C. Silurian and Devonian
 - D. Cambrian and Ordovician

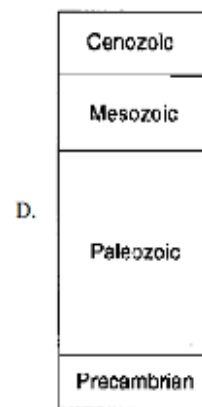
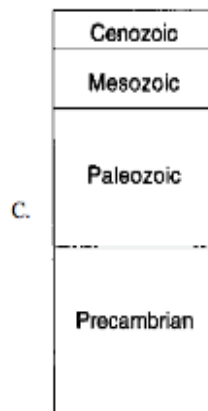
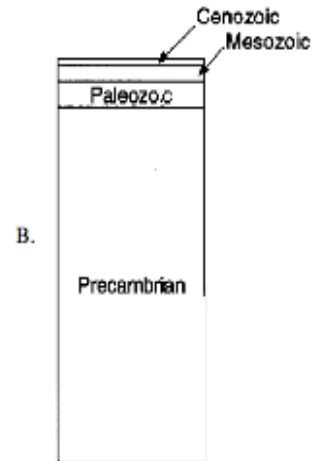
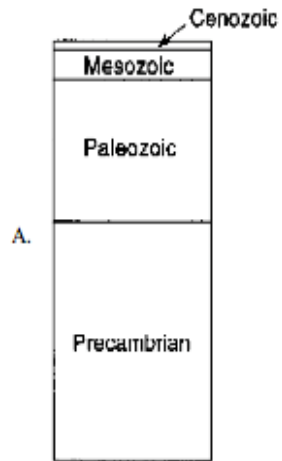
2. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, the cross section below, and your knowledge of Earth science. Letters *A* through *J* represent rock units. An unconformity is shown at letter *X*. A fault is shown at letter *Y*.



If rock layer *B* was deposited during the Carboniferous Period, igneous intrusion *H* could have occurred during the

- A. Cambrian Period B. Devonian Period
- C. Permian Period D. Silurian Period

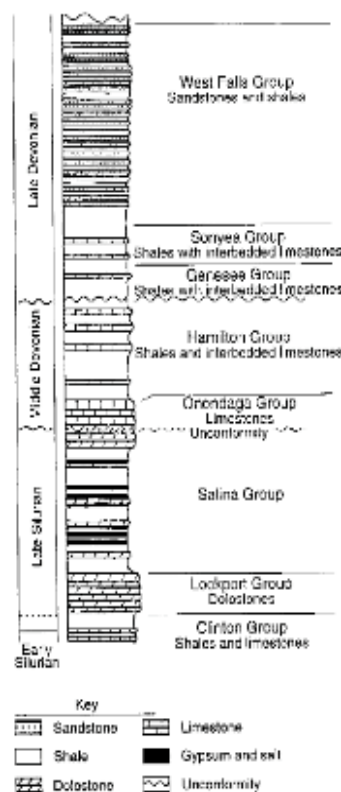
3. Which column best represents the relative lengths of time of the major intervals of geologic history?



4. Chemical evaporite bedrock is found approximately 20 kilometers south of Rochester, New York. This bedrock most likely formed during which geologic time interval?

A. Silurian Period
 B. Devonian Period
 C. Pleistocene Epoch
 D. Pennsylvanian Epoch

5. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, the geologic cross section of bedrock shown below, and your knowledge of Earth science. The cross section shows bedrock exposed along part of the Genesee River in New York State. The rock has not been overturned.



The bedrock shown in the cross section was formed during which geologic era?

- A. Proterozoic B. Paleozoic
 C. Mesozoic D. Cenozoic
6. What is the geologic age of the surface bedrock of most of the Allegheny Plateau landscape region in New York State?
- A. Cambrian B. Devonian
 C. Silurian D. Ordovician

7. New York State has no bedrock from which geologic time period?

A. Cambrian B. Devonian
C. Permian D. Cretaceous

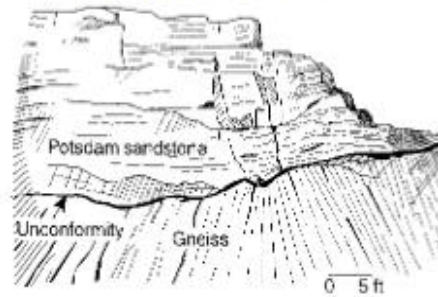
8. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, the map below, and your knowledge of Earth science. The arrows on the map show the location and orientation of glacial striations on the surface bedrock. Dark shading shows the location of large moraines (glacial deposits).



The Harbor Mill Moraine and the Ronkonkoma Moraine are believed to have formed during the

A. Jurassic Period
B. Cambrian Period
C. Pleistocene Epoch
D. Pennsylvanian Epoch

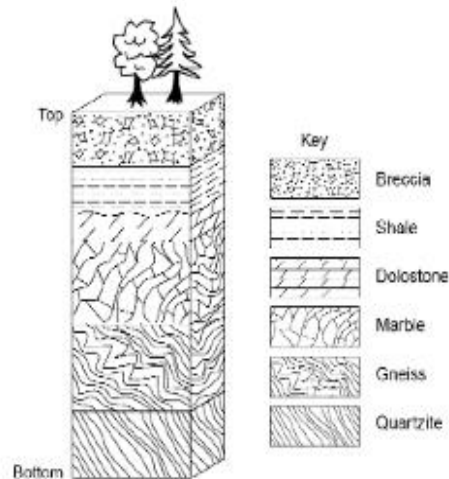
9. Base your answer(s) to the following question(s) on the diagram below. The diagram shows an outcrop of bedrock at the northern edge of the Adirondack Mountains in New York State.



The Potsdam sandstone is of Cambrian age. What must be the age of the gneiss?

A. Devonian B. Silurian
C. Tertiary D. Precambrian

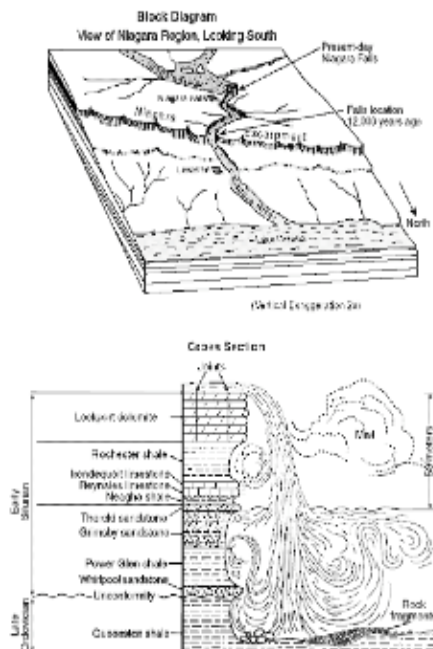
10. Base your answer(s) to the following question(s) on the diagram below, which represents a cross section of rock layers that have not been overturned.



If the breccia layer formed during the Carboniferous Period, the shale layer below it could have formed during which geologic time period?

A. Cretaceous B. Triassic
C. Permian D. Carboniferous

11. Base your answer(s) to the following question(s) on the 2001 edition of the *Earth Science Reference Tables*, the block diagram and the cross section below, and your knowledge of Earth science. The block diagram shows the present position of Niagara Falls in relation to the Niagara Escarpment. The cross section shows the general bedrock structure of present-day Niagara Falls.

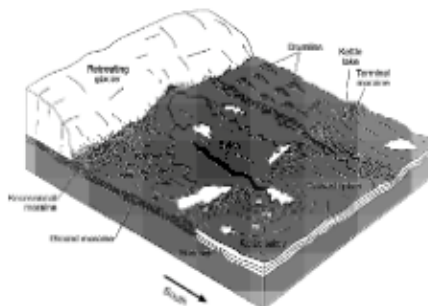


At the end of the glacial period, the Niagara River began flowing over the Niagara Escarpment. At the end of which epoch of geologic time did this situation occur?

- A. Pleistocene B. Pliocene
C. Miocene D. Oligocene
12. During which era did the initial opening of the present-day Atlantic Ocean most likely occur?

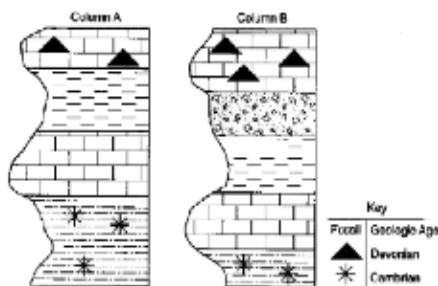
- A. Cenozoic B. Mesozoic
C. Paleozoic D. Late Proterozoic

13. Base your answer(s) to the following question(s) on the block diagram below, which shows some of the landscape features formed as the most recent continental glacier melted and retreated across western New York State.



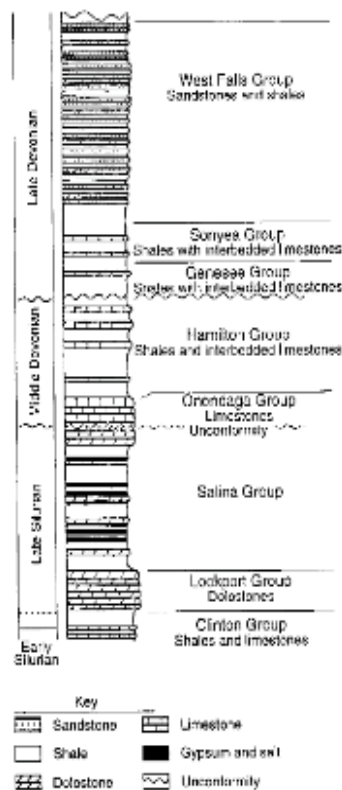
During which geologic epoch did this glacier retreat from New York State?

- A. Pleistocene B. Eocene
C. Late Pennsylvanian D. Early Mississippian
14. During which geologic time period did the earliest reptiles and great coal-forming forests exist?
- A. Devonian B. Quaternary
C. Mississippian D. Pennsylvanian
15. Base your answer(s) to the following question(s) on the diagrams below. Columns A and B represent two widely separated outcrops of rocks. The symbols show the rock types and the locations of fossils found in the rock layers. The rock layers have not been overturned.



State the oldest possible age, in millions of years, for the fossils in the siltstone layer.

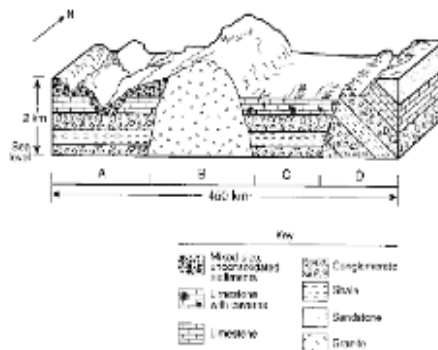
16. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, the geologic cross section of bedrock shown below, and your knowledge of Earth science. The cross section shows bedrock exposed along part of the Genesee River in New York State. The rock has not been overturned.



A fossil of which animal is most likely to be found in the bedrock of the Hamilton group?

- A. early reptile B. early dinosaur
C. brachiopod D. human

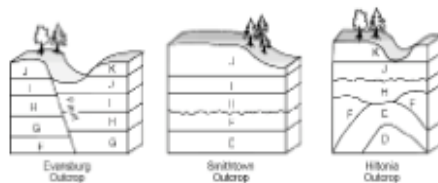
17. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, the geologic cross section below, and your knowledge of Earth science. The cross section represents an areal in which no overturning has occurred. Letters A, B, C, and D identify four landscape regions in this area. The vertical scale has been exaggerated.



A student searching for fossils would be least likely to find them in landscape region

- A. A B. B C. C D. D

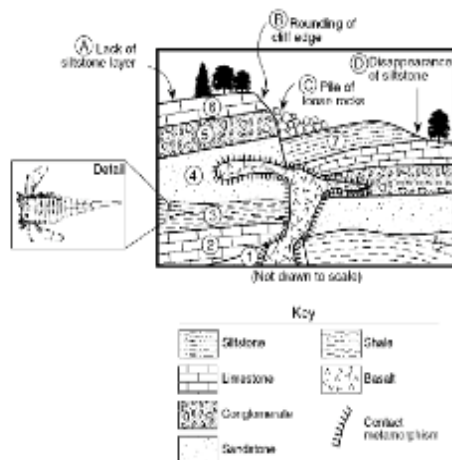
18. Base your answer(s) to the following question(s) on the *Earth Science Reference Tables*, your knowledge of Earth science, and the block diagrams below, which represent three widely separated outcrops. All rock layers are sedimentary. No overturning has occurred. Layers labeled with the same letter are the same age.



Layer I is of Permian age. Which fossil could be found in layer H?

- A. early flowering plant
B. early human
C. early reptile
D. early dinosaur

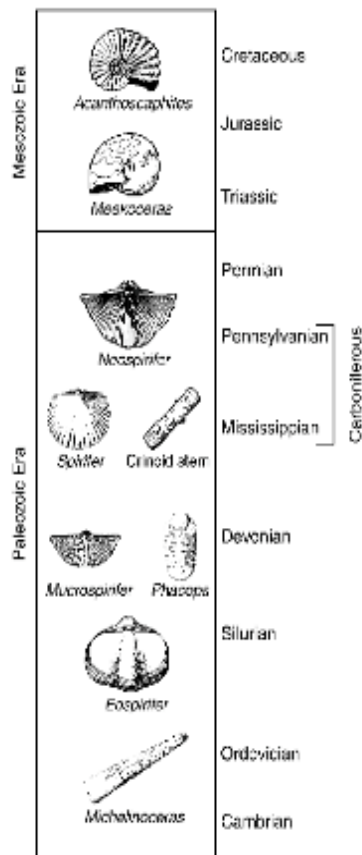
19. Base your answer(s) to the following question(s) on the diagram below of a cross section of a portion of Earth's crust. Letters A through D represent landscape features, and numbers 1 through 7 represent rock layers. The detail shows a fossil found in layer 3.



The fossil found in layer 3 indicates that the age of this shale layer is approximately

- A. 70 million years B. 220 million years
C. 430 million years D. 520 million years

20. Base your answer(s) to the following question(s) on the chart, which shows the geologic ages of some wellknown fossils.



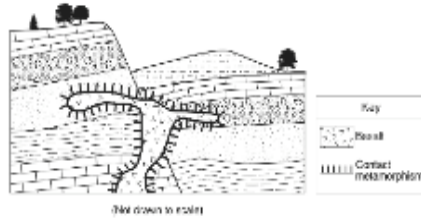
The *Spirifer*, Crinoid stem, and *Neospirifer* fossils might be found in some of the surface bedrock of which New York State landscape region?

- A. the Allegheny Plateau southeast of Jamestown
B. the Catskills near Slide Mountain
C. the Adirondack Mountains near Mt. Marcy
D. the Erie-Ontario Lowlands northeast of Niagara Falls

21. Which New York State fossil is found in rocks of the same period of geologic history as *Meekoceras*?

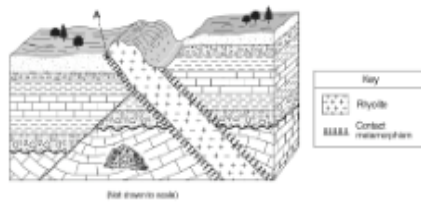
- A. Condor B. Placoderm fish
C. *Eurypterus* D. *Coelophysis*

22. Base your answer(s) to the following question(s) on the geologic cross section below. The rock layers have not been overturned.



The index fossil *Dicellograptus* was found in the shale layer. During which geologic time period did this shale layer form?

23. Base your answer(s) to the following question(s) on the block diagram below, which shows rock units that have not been overturned. Point A is located in the zone of contact metamorphism. A New York State index fossil is shown in one of the rock units.



Describe *one* piece of evidence that would indicate that the valley shown on the surface of the block diagram had been eroded and deepened by a glacier.

24. What evidence suggests that a mass extinction of the dinosaurs occurred at the end of the Cretaceous Period?

- A. an absence of dinosaur fossils in Paleocene bedrock
- B. drawings of dinosaurs made by humans in caves during the Paleocene Epoch
- C. an abundance of dinosaur fossils in Early Cretaceous bedrock
- D. evolution of dinosaurs during the Late Cretaceous Epoch

25. Base your answer to the following question on the passage and photograph below.

Dinosaur Tracks Revealed After Years of Dry Weather

By April 2005, the surface of Lake Powell, a human-made lake in Utah and Arizona, had fallen 145 feet below its highest level. This revealed many traces of ancient life that had not been observed since this area had been covered with water. Among these traces, discovered in sandstone bedrock, were many dinosaur tracks, ranging in age between 170 and 200 million years old.

**Dinosaur Track on Shoreline
of Lake Powell**



Source: Andre Delgalvis, *Arizona Highways*,
February 2006

The events listed below led to the formation and exposure of these dinosaur tracks.

- A. Rock layers above the dinosaur tracks are eroded.
- B. Tracks are made in loose sand by dinosaurs.
- C. Sediments are compressed and cemented.
- D. Sedimentation buries tracks.
- E. The water level of Lake Powell drops.

What is the correct sequence of the events listed above that led to the formation and exposure of the dinosaur tracks in the surface bedrock along the shoreline of Lake Powell?

- A. B → C → A → E → D
- B. B → D → C → A → E
- C. E → D → A → B → C
- D. E → C → B → D → A

APPENDIX C

POST UNIT INTERVIEW QUESTIONS FOR NON-TREATMENT UNIT

1. Do you find it difficult to concentrate in class when the teacher is talking? Explain.
2. Do you take careful notes? Explain.
3. Describe what you are thinking when you are taking notes. For example, are you able to process information as you write notes and listen to the teacher? Are you able to generate questions?
4. Do you remember what you hear during in class lectures? Explain.
5. Do you feel comfortable asking questions in our large group when you are confused? Explain.
6. Do you use your notes to study for exams?
7. Is an in class teacher lecture an effective method for you to learn information? Why or why not?
8. Do you give up at home when you cannot initially complete a problem? Why or why not?
9. Draw four horizontal layers of rock.
10. Label them from the top down, A, B, C, and D.
11. Which of these layers is youngest, and how do you know?
12. You find a trilobite in layer C, and you find a fish fossil in layer B. How does this evidence support the statement that B is younger than C?
13. How do faults and igneous intrusions help us to infer relative ages in rock outcrops?

APPENDIX D

POST UNIT INTERVIEW QUESTIONS FOR TREATMENT UNIT

1. Do you find it difficult to concentrate at home when watching teacher videos? Why or why not?
2. Do you think that you take careful notes at home? Did your grades reflect your thoughts on this?
3. Describe what you are thinking when you are taking notes. For example, are you able to process information as you write notes and listen to the teacher video? Are you able to generate questions to be answered once you get to class?
4. Do you remember what you watch and hear when playing teacher videos at home? Explain.
5. Do you feel comfortable asking questions in our small groups when you are confused in class? Explain.
6. Do you use your notes to study for exams?
7. Is video lecture with follow-up practice in class an effective method for you to learn information? Why or why not?
8. Are you doing other things while the video is playing? Please give an example.
9. If you wanted to find an absolute age for a fossil bone that was 15,000 years old, how would you do it?
10. Which radioactive isotope would you use?
11. Why would you choose that isotope?
12. How does that isotope give you an age?
13. Draw a general graph that shows the radioactive decay curve.

APPENDIX E

SAMPLE CAT FOR NON-TREATMENT UNIT

1. List 1 example of an index fossil from the Devonian Period (use a letter from the Geologic Time Scale as your answer).
2. In rock layer A, you find a fossil of a placoderm fish. In rock layer B, you find a fossil of a bird. Which layer is older?
3. Explain how you got the answer to # 2.
4. In which geologic time period did the uplift of the Adirondack Mountains begin?
5. List the periods of the Mesozoic Era.

APPENDIX F

SAMPLE CAT FOR TREATMENT UNIT

1. Draw a graph that shows the curve for exponential growth.
2. Draw a curve that shows the curve for exponential decay.
3. For all radioactive isotopes, what percentage of the parent material remains after:
 - a. one $\frac{1}{2}$ life?
 - b. two $\frac{1}{2}$ lives?
 - c. three $\frac{1}{2}$ lives?
4. For all radioactive isotopes, what percentage of decay product exists after:
 - a. one $\frac{1}{2}$ life?
 - b. two $\frac{1}{2}$ lives?
 - c. three $\frac{1}{2}$ lives?
5. Define the term *half-life*

APPENDIX G

POST UNIT SURVEY FOR NON-TREATMENT UNIT

This survey is voluntary and has no effect on your grade.

1 = Strongly Disagree 2 = Disagree 3 = Indifferent 4 = Agree 5 = Strongly Agree

- | | | | | | |
|---|---|---|---|---|---|
| 1. I find it easy to practice science concepts at home by myself. | 1 | 2 | 3 | 4 | 5 |
| 2. I like it when the teacher delivers notes in class. | 1 | 2 | 3 | 4 | 5 |
| 3. I benefit from class discussion during teacher lectures in class. | 1 | 2 | 3 | 4 | 5 |
| 4. I usually “zone out” when the teacher lectures in class. | 1 | 2 | 3 | 4 | 5 |
| 5. My homework answers are usually correct. | 1 | 2 | 3 | 4 | 5 |
| 6. The teacher lectures too fast for me to absorb information in class. | 1 | 2 | 3 | 4 | 5 |
| 7. I like having live lectures so that I can ask questions right away. | 1 | 2 | 3 | 4 | 5 |
| 8. I don’t need teacher lectures to understand the Earth science concepts. | 1 | 2 | 3 | 4 | 5 |
| 9. I reread my science notes to prepare for exams. | 1 | 2 | 3 | 4 | 5 |
| 10. I feel stupid asking questions in class if I don’t understand. | 1 | 2 | 3 | 4 | 5 |
| 11. I have trouble interpreting new graphs. | 1 | 2 | 3 | 4 | 5 |
| 12. Graphs help me to understand data. | 1 | 2 | 3 | 4 | 5 |
| 13. What are your biggest challenges when taking notes in class on a challenging topic? | | | | | |
| 14. Did the strategies that we employed in class during this unit help you to become better at remembering the material? Explain. | | | | | |
| 15. Are you more confident with graph and data table interpretation? Explain. | | | | | |

APPENDIX H

POST UNIT SURVEY FOR TREATMENT UNIT

This survey is voluntary and has no effect on your grade.

1 = Strongly Disagree 2 = Disagree 3 = Indifferent 4 = Agree 5 = Strongly Agree

- | | | | | | |
|---|---|---|---|---|---|
| 1. I find it easy to practice science concepts at home by myself. | 1 | 2 | 3 | 4 | 5 |
| 2. I like watching teacher videos at home. | 1 | 2 | 3 | 4 | 5 |
| 3. I miss class discussion during teacher lectures in class. | 1 | 2 | 3 | 4 | 5 |
| 4. I multi-task during teacher videos at home. | 1 | 2 | 3 | 4 | 5 |
| 5. My homework notes are thorough, and I get a good grade on them. | 1 | 2 | 3 | 4 | 5 |
| 6. I pause the video when taking notes from teacher videos. | 1 | 2 | 3 | 4 | 5 |
| 7. I like having the option to pause teacher videos. | 1 | 2 | 3 | 4 | 5 |
| 8. I don't need teacher lectures to understand the Earth science concepts. | 1 | 2 | 3 | 4 | 5 |
| 9. I reread my science notes to prepare for exams. | 1 | 2 | 3 | 4 | 5 |
| 10. I like having time in class to practice concepts. | 1 | 2 | 3 | 4 | 5 |
| 11. I have trouble interpreting new graphs. | 1 | 2 | 3 | 4 | 5 |
| 12. Graphs help me to understand data. | 1 | 2 | 3 | 4 | 5 |
| 13. Having more time to practice in class is making science easier for me. | 1 | 2 | 3 | 4 | 5 |
| 14. What are your biggest challenges when taking notes at home on a challenging topic? | | | | | |
| 15. Did the strategies that we employed in class during this unit help you to become better at remembering the material? Explain. | | | | | |
| 16. Are you more confident with graph and data table interpretation? Explain. | | | | | |

APPENDIX I

SAMPLE OF TEACHER JOURNAL ENTRY FOR NON-TREATMENT UNIT

Teacher: Heather Renyck	Date: January 23, 2015
N or T? Non-treatment Unit	Lesson Concept: Principles of Relative Age
Class Observed: 5 th period	
Group 1 = high achiever, Group 2 = Average Achiever, Group 3 = Low Achiever	
Approach: CAT 1 was administered. Students were given one principle after the next. Each one was written on the document projector for students to record into their notebooks. An example was given for each principle using a prop (like foam rock layers, for example). Students were given a few questions to answer immediately after each principle was presented. Photographs of rock layers were also shown.	
How many students were “zoning out?” four: (1 female from Gp. 1, 2 males from Gp.1, 1 female from Gp. 2)	How many students were visibly distracted by peers? three: (all males from Gp. 2)
How many students answer questions orally today? 12 out of 20 (males and females from all groups were represented)	What was the mood today? Normal for this class – I had to redirect the usual crowd on occasion
How did this lesson go? Not bad. Many of the students did well on CAT 1. Using the Styrofoam layers always works for Original Horizontality and Superposition. Some of the IEP students struggled with the examples that they had to complete on their own. Miss Kirnan and I guided them through those. It was a comfortable lesson for me, but time will tell if the students will be able to retain the information and do well on CAT 2 tomorrow. Ryan was a little more hyper than usual. I noticed that he did not go to the nurse to take his meds., and I forgot to remind him.	

APPENDIX J

SAMPLE OF TEACHER JOURNAL ENTRY FOR TREATMENT UNIT

Teacher: Heather Renyck	Date: February 12, 2015
N or T? Treatment Unit	Lesson Concept: The Decay Curve
Class Observed: 5 th period	
Group 1 = high achiever, Group 2 = Average Achiever, Group 3 = Low Achiever	
Approach: CAT 1 was administered. Students were given an open-note quiz on video 1. Since we completed the Decay-Curve Lab yesterday, I was able to use decay curve questions on CAT 1. Then we took most of class to work on practice problems. Video 2 was assigned.	
How many students were “zoning out?” Zero!	How many students were visibly distracted by peers? Tough call – I had to redirect a lot of students, but they were working in addition to chatting with each other
How many students answer questions orally today? Five (during the time that we went over CAT 1 after students submitted their work to me): All answers came from boys today, and each ability group was represented.	What was the mood today? Lively and a little chaotic. This is a big class with many students who are distracted by each other. I was probably visibly stressed, but with some redirection, most students appeared to be on-task. Miss Kirnan was here to help and that makes a really big difference for the better!

How did this lesson go?

I am a little frustrated by the 4 students who claimed that they had technical difficulties with the video (especially since 3 of them had my DVDs!), so I had to put 4 students on computers. I made them take the open-note quiz with us before watching the video. I wanted them to know that there would be consequences for not completing the homework. It felt cruel, as 2 of those students with technical difficulties are not the type to make excuses – Mike and Broc. At least it wasn't as bad as 3rd periods where 7 of the 13 students did not complete their homework.

For those who did complete their homework, some gave me feedback about the volume of the video stating that it was too low. I'll have to fix that for the next one, and hopefully video 2 is loud enough for them since it's already uploaded.

Time will tell if the practice today was useful. Aye... I don't know if I have it in me to stick with this after AR.

APPENDIX K
GENERAL TIMELINE

General Timeline:

January 19, 2015: Start Project Implementation

January 19 – February 4, 2015: Nontreatment Unit with Routine Teaching Strategies, 2 weeks – Relative Age Methods in Geology (including interpretation of the Geologic Time Scale)

February 5 – February 24, 2015: Treatment Units 2 weeks – Absolute Age Dating Methods

February 25, 2015: End Project Implementation

APPENDIX L
IRB EXEMPTION FORM



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

960 Technology Blvd. Room 127
 c/o Immunology & Infectious Diseases
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
 FAX: 406-994-4303
 E-mail: cherylj@montana.edu

Chair: Mark Quinn
 406-994-5721
 mquinn@montana.edu
Administrator:
 Cheryl Johnson
 406-994-6783
 cherylj@montana.edu

MEMORANDUM

TO: Heather Renyck and Walt Woolbaugh

FROM: Mark Quinn *Mark Quinn*

DATE: January 28, 2015

RE: "The Effects of Flipping the Earth Science Classroom on Student Outcomes, Student Attitudes, and Teacher Attitudes" [HR012815-EX]

The above research, described in your submission of **January 14, 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:

- X (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.
- X (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 M
NON-CONTENT-RELATED INTERVIEW QUESTIONS AND RESPONSES FOR
POST-NON-TREATMENT UNIT

Question #	Question
1	Do you find it difficult to concentrate in class when the teacher is talking? Explain.
2	Do you think that you take careful notes? Explain.
3	Describe what you are thinking when you are taking notes?
4	Do you remember what you hear during class lectures? Explain.
5	Do you feel comfortable asking questions in our large groups when you are confused? Explain.
6	Do you use your notes when you are studying for exams?
7	Is an in-house teacher lecture an effective method for you to learn information? Why or why not?
8	Do you give up at home when you cannot initially solve a problem? Why or why not?

Ques. #	Common Responses from Group 1	Common Responses from Group 2	Common Responses from Group 3
1	All answered no and felt that the class was not difficult	60% answered no and 40% stated that they get distracted by others or daydream	All thought that the lectures were too fast and/or they got distracted
2	All felt that they took good notes, but no student wrote anything extra	70% stated yes, and 30% felt that distracted	80% thought that they take good notes, and 20% cannot read their own notes
3	50% of the students generated questions during note-taking, and 50% of the students focused on writing	All were focused on the words are were not thinking about anything else	All were focused on the words are were not thinking about anything else
4	80% of these students remembered what they heard, and 20% needed to review	None remembered, and all needed the next day to review in class	One student remembered, and all others relied on review in class
5	All felt comfortable asking questions in class	80% felt comfortable, and 20% felt uncomfortable but were willing to ask after class	40% felt comfortable, and 60% felt judged by others or insecure
6	All used their notes to study	70% used notes to study, and 30% stated that they do not study at all	50% used notes to study, and 50% stated that they do not study at all
7	All liked in-house lectures due to demonstrations and discussions	70% liked lectures and demonstrations, and 30% felt distracted or bored	60% liked lectures and demonstrations, and 40% felt distracted or bored
8	All persisted because they usually understood	50% gave up, and 50% sought outside help	All students gave up (due to no outside help)

APPENDIX N
NON-CONTENT-RELATED INTERVIEW QUESTIONS AND RESPONSES FOR
POST-TREATMENT UNIT

Question #	Question
1	Do you find it difficult to concentrate at home while watching the teacher videos? Why or why not?
2	Do you think that you take careful notes at home? Did your grades reflect your thoughts on this?
3	Describe what you are thinking when you are taking notes?
4	Do you remember what you watch and hear while you are watching teacher videos at home? Explain.
5	Do you feel comfortable asking questions in our small groups when you are confused in class? Explain.
6	Do you use your notes when you are studying for exams?
7	Is video lecture with follow-up practice in class an effective method for you to learn information? Why or why not?
8	Are you doing other things while the video is playing at home? If so, please provide an example.

Ques. #	Common Responses from Group 1	Common Responses from Group 2	Common Responses from Group 3
1	No one found it to be difficult and thought that the videos were short enough	50% did not find it difficult to focus, and 50% did find it difficult to focus due to home distractions	40% did not find it difficult to focus, and 60% did find it difficult to focus due to home distractions
2	All felt that their notes were good and that their grades reflected this	50% stated yes and 50% stated no, and all students felt that their grades reflected this	60% stated yes and 40% stated no and all students felt that their grades reflected this
3	All answered that they were just focused on completing the guided worksheet	All answered that they were just focused on completing the guided worksheet	All answered that they were just focused on completing the guided worksheet
4	80% of these students remembered what they heard and watched, and 20% needed to review	60% of these students remembered what they heard and watched, and 40% needed to review	40% of these students remembered what they heard and watched, and 60% needed to review
5	All felt comfortable asking questions in class	All felt comfortable asking questions in class	80% felt comfortable, and 20% felt judged by others or insecure
6	All used their notes to study	60% used notes to study, and 40% stated that they do not study at all	50% used notes to study, and 50% stated that they do not study at all
7	All stated that videos were effective, but 70% liked in-house lectures better	All stated that they liked the practice in class, but none liked to watch videos at home	40% liked the flipped classroom approach, and 60% liked the in-class practice but none liked the videos
8	80% focused on video alone, and 20% multi-tasked	20% focused on video, and 80% multi-tasked due to distractions	50% focused on video, and 50% multi-tasked due to distractions