

THE EFFECT OF THE FLIPPED CLASSROOM ON
ACHIEVEMENT AND ENGAGEMENT IN A
7TH GRADE SCIENCE CLASSROOM

by

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ABSTRACT

This paper sought to analyze the effects of the flipped classroom on achievement and engagement in a 7th grade science classroom at an International School in Shanghai, China. Student perceptions about the flipped classroom were also analyzed along with a discussion about its implications in the classroom. The study was conducted for the course of eight weeks. For four weeks (nontreatment period) three classes were exposed to the traditional instructional format where higher order thinking assignments were sent home as homework. This was followed by another four weeks (treatment period) where the higher order thinking assignments were completed during the end of the class and a flipped video was sent home as homework as an introductory to the next day's lesson. While this change may seem insignificant, it was designed to allow students more time in class to collaborate and seek out help on the higher-level learning. By watching the videos at home, time that was traditionally used to introduce the day's lesson was no longer necessary. The results revealed that the flipped classroom had a positive impact on achievement for most students - including low performing students; had a mixed impact on engagement and attitude by gender – females showed improved attitudes while males remained largely unchanged; and it was perceived as a favorable method of instruction for most students.

INTRODUCTION AND BACKGROUND

Flipped Learning Context

Flipped learning is structured in numerous ways for various purposes. In this study, flipped learning will be defined as a method of instruction where basic concepts are presented through video or other technology as homework in preparation for higher-level learning in the classroom. Flipped classrooms are becoming more common in k-12 and university settings. Although the reviews are mixed, a strong body of research indicates that when flipped learning classrooms are implemented in k-12 environments, achievement and attitudes may improve over more traditional approaches to learning (*Info-graphic on teacher and student engagement*, 2012).

Purpose

With this context in mind, I wanted to create more time for students to engage in science during our Thinking like a Scientist unit, a unit broken into three parts: hands-on science experiments, hands-on engineering investigations, and independent science and engineering investigations. Students should be engaged in inquiry investigations and critical thinking as much as possible during class. The time I spend in class providing background knowledge and instructions takes away from higher level learning experiences.

This study is significant for several reasons. First of all, our school's recent adoption of the Next Generation Science Standards calls for more emphasis on the science and engineering practices in order to make sense of the world. The Practices are taught using the Tool for Storyline Coherence Template, as presented by Brian Reiser at

the 2015 NGSS@NSTA Conference in Chicago: questions are geared around a phenomenon, investigated through scientific and engineering practices, ending in students figuring out the why and how as a way of knowing the content, rather than the reverse that was formally taught (Reiser, 2015).

Currently the questions and phenomena are explored during class along with the investigations; however, the why and how part goes home as homework. First, I anticipate that students' scores in the flipped-classroom will show higher levels of learning than in the non-flipped classroom because of more teacher/peer contact time.

Second, I anticipate that student attitudes will change and favor the flipped classroom over the non-flipped classroom. Also, I hope to determine how student science and engineering attitudes change with the flipped classroom.

Third, this study will provide our STEM coach key information in determining a possible pedagogy in which more class time can be devoted to coaching students to think critically about the disciplinary core ideas and cross-cutting concepts while engaging in science and engineering practices.

Last of all, I anticipate this study to impact me directly. It will help me better understand the pros and cons of using the flipped classroom. It will also help me determine if the extra class time freed up with a flipped classroom actually increases student achievement and attitudes. Since the flipped classroom requires students to watch video or engage in online learning at home as homework, I will be able to determine whether the flipped classroom can be supported in China where the internet is censored

and has streaming issues. Most importantly, I hope to determine if all of the extra time and effort of creating a flipped classroom is worth it.

Research Questions

This action research project involves three primary questions. First, I would like to determine how flipping the classroom effects student achievement during two science modules; the nature of science practices and the nature of engineering practices. My additional questions attempt to determine how student engagement and attitudes change and how students perceive the flipped classroom as a method of learning. My specific research questions are as follows:

Primary Question:

In what ways are student higher order thinking skills or achievement impacted by the flipped classroom?

Sub Questions

- 1: To what extent does the flipped classroom impact student engagement, measured by attitudes?
- 2: What perceptions do students have about the flipped classroom as compared to the traditional classroom?

Support Team

As I worked through the results of my action research, I shared the information with several key people: Lisa Hawkins, Tina Harbold, Michael Schulteis, and Joseph Bradshaw.

Mrs. Lisa Hawkins is my STEM coach and my Grade 7 teaching partner. She is interested in the results as we look at ways to maximize critical thinking and engagement in the middle school classroom. I shared my findings with Lisa during our regular science meetings and during scheduled planning periods.

Dr. Tina Harbold is my other science teaching partner. She has a keen eye for detail and was crucial in helping me sift through my data to create meaning. I shared my work with Tina during our weekly planning meetings.

Dr. Michael Schulte is another colleague that teaches 8th grade science. He has background not only in science, but expertise in research. He was on the faculty at Concordia University – Irvine, and was responsible for overseeing student educational research. I met with Michael several times after school to look over the mechanics and layout of the written report.

Joe Bradshaw works in the Department of Intercollege Programs for Science Education at Montana State University. He has expertise in Ecology and Biology with a MEd in Curriculum and Instruction. He agreed to be my science reader throughout the capstone editing process.

CONCEPTUAL FRAMEWORK

The Flipped Classroom

The flipped classroom is becoming popular among educators. Many universities and K-12 learning communities are either experimenting with it or have made it part of their everyday pedagogy. The benefits and positive impact are numerous for both instruction and learning. Research has shown improvements in attitude, motivation, and

achievement over the traditional classroom, although some data notes the benefits are not significant. In general, flipping the classroom entails flipping the typical lecture and homework: what was once completed as homework is completed in the classroom and what was once completed in the classroom – typically the lecture – is now completed at home (Bergmann & Sams, 2012). The flipped classroom has moved well beyond the basic model to a variety of different learning models with a focus on higher-order thinking, differentiation, and mastery.

History and Evolution of the Flipped Classroom

The current traditional model of instruction can be traced back to Horace Mann and the Industrial Revolution. Mann believed that schools could bring about a unity and purpose that the United States, being a nation of immigrants, lacked. He believed the factory model exemplified by the Industrial Revolution was the model to be emulated. Large group instruction became commonplace and was viewed as an efficient way to structure schools. Instruction was taught in one-size fits all format. This impersonal approach to instruction became the norm throughout the centuries to the present (Rose, 2012).

Dewey, Bruner, and Piaget later followed in the footsteps of Mann and began to push for other models of learning. Dewey believed in the constructivist theory in which learning was viewed as experiential, one in which students contextualized learning – much like we would call experiential learning today. Piaget believed learning needed to be active, where testing and iteration took the place of lectures as a better match for the varied stages of learning. Bruner brought to the table the idea of socialization. He said

that students learn best through interacting with their peers through discussion, argumentation, and reflection ("Education theory/constructivism", n.d.).

The computer ushered in a new method of learning with digital technology in the late 20th Century. Although it was hoped that it would revolutionize education, research has verified that the computer has had little effect on student learning. The computer tended to become just another tool within the old factory model of learning - class lectures continued and homework was completed in the evening at home (Rose, 2012).

Today students have more than just a computer at their disposal with multiple forms of digital devices that can access the Internet almost upon demand. Schools are all wired and media is commonplace within many classrooms, the workplace, and homes. Many educators are once again challenging the traditional classroom to be more student friendly, student centered, and personal. The flipped classroom can be a transforming model to achieve this ("Flipped classroom - unlimited personalized lessons from Knewton", 2012).

The majority of students in classrooms today are classified as Generation Z students who were born between 1996 and 2010. Their learning has been influenced by the internet, smart phones, and social media. This is the connected generation. Surveys reveal the following preferences for learning: 43% would rather learn through the Internet; 38% would rather learn through digital formats; and 16% prefer text written media such as books ("Consumers of tomorrow: insights and observations about generation z", 2011).

The flipped classroom concept has evolved to embrace many different models of learning, but all premised on the idea that lower level learning tasks are done at home using digital technology and the work involving Benjamin Bloom's revised taxonomy of cognitive domains (Anderson & Krathwohl, 2001) are done during the class time (Bergmann & Sams, 2014). It is a system in which students receive direct instruction outside of class while group work, individualized instruction, individual attention, and differentiation occurs within the classroom (Bergmann & Sams, 2015).

The flipped classroom also provides a venue for developing critical thinking. During the classroom phase of the flipped classroom, students apply Bloom's higher levels of learning (Addy, LePrevost & Stevenson, 2014). The Next Generation Science Standards, NGSS, provides teachers with support in ensuring critical thinking is occurring in the classrooms. The NGSS curriculum is based upon three-dimensional thinking and inquiry-based problem solving. Students explain, discuss, explore, and engage in argumentation during class instruction; this is where the higher-levels of learning occur ("NGSS Hub", 2013).

Two earlier models of the flipped classroom – the inverted class and peer instruction – used science class time to develop critical thinking. A Macroeconomics professor at Miami University in Ohio inverted his class and assigned homework in the form of video lectures, readings, and slideshows, and class time was spent on investigations, labs, collaboration, and critical thinking (Lage, Platt & Treglia, 2000). Eric Mazur developed another form of the flipped class called peer instruction. He assigned his physics students notes and readings to complete as homework and then spent

class time administering short quizzes, collaborative instruction, argumentation, and models of learning where the students taught others. Lower-level learning occurred as homework and higher-level critical thinking occurred during class (Mazur, 2014).

The inverted classroom and peer instruction represented early models of what later would be called the flipped classroom. Jonathan Bergmann and Aaron Sams popularized it in 2007. Interestingly they both struggled to find a name that would stick until author Daniel Pink wrote an article about Karl Fisch's flipped math classroom. (Pink, 2010). Bergmann and Sams' story is interesting. They were tutoring students in chemistry and realized that this was a need that needed to be addressed. In 2007 Aaron came across an article and shared it with Jon. The article discussed how voice-over and annotations could be added to a slideshow. Using this idea, they posted their next lectures online and the feedback was overwhelming. Students commented on how the videos helped them learn better (Bergmann, 2011).

Flipped mastery learning has recently evolved from the flipped classroom concept. Flipped learning distinguishes itself from the flipped classroom in that it seeks to incorporate four pillars: a flexible environment, a culture of learning, intentional content, and strong supportive role of a professional educator. In the flipped learning model, the learning shifts from a teacher-centered to a student-centered environment where students explore content in-depth in ways that involve high-level thinking and metacognition. Planned content drives the model; the teacher distinguishes between that which should be taught and that which should be student driven to maximize learning, engagement, and use of class time. Last of all, the flipped learning concept involves a professional teacher

who provides constant informal and formative feedback and provides guidance and structure to the learning process (*What is flipped learning?*, 2014)

Mastery learning is another type of flipped classroom derived from flipped learning. John Bergmann noticed that at the end of the semester in one of his science classes, students were not able to answer the key conceptual questions for the course even though they had been using the flipped classroom. This is when he had his Eureka moment! He developed a flipped classroom that was based upon mastery learning – in which 75 percent of the material must be mastered before moving on. This model allowed him to differentiate and help all students – those that are struggling and those that are excelling (Bergman, 2016).

The Flipped Classroom Model is yet another model for flipping the classroom (Gerstein, 2012). Developed by Jackie Gerstein, PhD, The Flipped Classroom Model blends parts of the experiential learning cycles (Greenaway, n.d.) and the 4Mat Cycle of Instruction (McCarthy & McCarthy, 2006). The Flipped Classroom Model is designed to maximize the learning that occurs in the classroom through four steps: experiential engagement, concept exploration, meaning making, and demonstration/application. She emphasizes that the flipped classroom should be considered only a part of the learning process and instruction (Gerstein, 2012).

Impact of the Flipped Classroom

The flipped classroom has become part of many K-12 classrooms and schools, driven by below standard school performance and the simplicity of online video ("Flipped classroom - unlimited personalized lessons from Knewton", 2012). Research

has been supportive of its benefits to learning and has noted it as a positive transition from the traditional classroom. One survey of 452 educators indicated some of the general impacts of the flipped classroom on both teachers and students. Eighty-five percent of the survey respondents were teaching seven or more years and 91% had used the model less than two years. Forty-six percent of the respondents were science teachers, compared to 32 % in math and 12 % in English Language Learning classes. Last of all, 95 % of the respondents were in secondary schools. Data from the survey revealed its impact on teachers: 88 % said their job satisfaction improved and 46 % said it improved significantly. Forty-three percent have put more than 50 % of their instruction online and 28 % indicated that more than 75 % of their instruction was online. The survey also revealed some significant impacts on student standardized test scores and attitudes – as revealed by the teachers who instructed them. Sixty-seven percent reported that test scores improved and 80% revealed that student attitudes improved. It was reported that the benefits were widespread, for both AP students and special needs students (*Infographic on teacher and student engagement*, 2012).

Flipped Learning and Academic Gains/Attitudes

Research studies support that the flipped classroom improves student learning and attitudes. Although it is not possible to represent all existing studies, several secondary and postsecondary are worthy of mention. Results from Spartan college of Aeronautics and Technology show 14.7% more students passed the FAA Flight Tests and 8.9% more passed the FAA Knowledge Tests when learning in a flipped classroom (Smith, 2014).

Survey results from high school students in Okanagan, Canada, benefited from flipped math classrooms where 84% agreed or strongly agreed that the flipped classroom was more engaging than the traditional classroom, while 5% disagreed. Eighty-five percent of the students agreed or strongly agreed that the flipped classroom increased students' opportunities to communicate. Six percent of the students did not feel that their learning had improved. These students also said that they found value in more active-based activities during class time, valued the self-pacing component, and recommended more interactive videos (Johnson, 2013).

At Villanova a flipped engineering course showed student gains of 10% for students in the bottom third of the class (Bidwell, 2014). This suggests that the flipped classroom may impact struggling students.

Scott Freeman at the University of Washington began flipping his biology class by having students prepare for class with selected background readings and online quizzes, and using clickers and interactive discussions during class. Failure rates went from 17% to 4% and students scoring A's in the class increased from 14% to 24% (Aronson & Arfstrom, 2013).

In a rural US high school, an Algebra II/Trigonometry class flipped the lectures with video podcasts. During class, students worked collaboratively on problem solving, projects, and authentic learning. The flipped classroom's GPA was approximately 0.8% points higher than the traditional classroom and 11% more students received an A in the flipped classroom. (Szoka, 2013).

Clintondale High School in Michigan began to flip their classrooms in 2010. Now all classrooms are following the traditional flipped model in which students watch teacher lectures at home and then engage in higher order thinking, collaborations, and real world learning during the classroom. After their first year of study, their freshman class had 33% less failures in language arts, 31% less in math, and 22% less in science and social studies. They also measured a 66% drop in discipline problems ("Clintondale high school - our story", 2012).

At Byron High School in Minnesota, Troy Faulkner flipped his math classroom where only 30% were meeting the proficiency standard. Students watched interactive video lectures at home and then used class time for working on problems, formative assessment, discussions, and collaborations. In comparing the 2007-2010 data from his traditional math classes to the 2010-2013 data obtained from his flipped classrooms, there was an average increase in proficiency of about 10% across the board. Surveys revealed that 87% of the parents favored the flipped classroom over the traditional. Ninety-five percent of the students favored the flipped classroom (*Flipped learning model increases student engagement and performance*, 2013).

A 2013 study conducted by a student at Montana State University on her High School Environmental Systems and Society course conducted an action research project in which students watched video lectures at home and worked on assignments during class. Grades improved by about three percent. Lower performing students saw the greatest gains in grades, which the teacher attributed possibly to more one-on-one

interaction with the teacher and increased group work during class time. The students also indicated lower stress levels (Marlowe, 2012).

Research also indicates that the flipped classroom does not always lead to significant gains. Known for its hands-on learning environment, Harvey Mudd College in California is conducting a 4-year study on flipping a class on differential equations. Two years into the study show no significant gains in learning or attitudes. This is possibly due to the highly interactive lectures (Yong, Levy & Lape, 2015).

Another research study shows similar results from a university in the western United States. Students in a general biology class participated in a flipped class. Rather than comparing it to a traditional lecture classroom, the flipped classroom was compared to an active classroom using the BSCS 5E Instructional Model – a delivery method known for its engaging qualities (Bybee, 2015). Researchers discovered that differences in students' attitudes and learning were not significant, suggesting that the flipped classroom had similar results to non-flipped, but engaging classrooms (Jensen, Kummer & Godoy, 2015).

A doctoral dissertation was completed by Donna Howell in a Grade 9 Honors Physics class in a rural school in the United States. The racial mix was diverse consisting of about two-thirds Caucasian and one-third African American. Overall there was not a significant change in performance of the students, although in one unit Caucasian students scored higher. However, more parents and students indicated they preferred the flipped classroom over the traditional classroom (Howell, 2013).

Research reveals a wide variety of styles and techniques for flipping the classroom. The flipped class is an umbrella concept that includes the traditional Flipped Classroom, Peer Instruction, the Inverted Classroom, Flipped Learning, Flipped Mastery Learning, The Flipped Classroom Model, and more. All models include a technological component at-home followed by a student centered in-class experience. While much of the research indicates it improves student learning and attitudes, many studies also indicate that when compared to more engaging classroom models, the impact is less significant and negligible. Overall, the key to designing a flipped classroom is to ensure the students are fully engaged in both parts of the “flip” and that classroom time is truly differentiated, learner focused and student led, and engaging. Bergman and Sams reiterate that the flipped classroom should be tailored to each school community and learning needs of its students, resulting in a different blend among classrooms and communities (Bergmann & Sams, 2015).

METHODOLOGY

Participants

The study included 48 students from a 7th grade classroom at an English speaking international school in Shanghai, China. The school was composed of 1,200 students from 32 nations, used an American curriculum, and was accredited by the Western Association of Schools and Colleges (WASC) - a US-based accreditation organization – and the National Lutheran School Accreditation (NLSA). The three classes under study included 48 students of which 23 (48%) were female and 25 (52%) were male. The demographics for the three classes consisted of 57% Asian/Pacific Islander, 26%

White/Caucasian, 11% Mix, 4% American Indian, and 4% Latino/Hispanic. The socioeconomic status of the families was upper middle class to the very affluent. The parents of the students were well educated of which more than 50% of both parents had a graduate degree or higher. All students had two parents living in their household, however often one parent was away traveling on business.

Purpose

The purpose of this classroom research project was to compare the effects of the flipped classroom on achievement, engagement/attitude, and perceptions to the traditional classroom delivery method. The capstone involved three grade seven science classes as they went through the Science and Engineering Practices Unit. All three classes began with the nontreatment for four weeks using the traditional model where written homework (higher level) was sent home and ended with the treatment for four weeks where homework became an introduction (low level) video/digital assignment that introduced students to the following day's topic.

Intervention

The science and engineering practices unit utilized a template called A Tool for Storyline Coherence. This storyline was broken into four phases: questions; phenomena; practice engagement; sense making (Reiser, 2015). Assembled together, questions were geared around a phenomenon, investigated through scientific or engineering practices, followed by students figuring out the why and how as a way of knowing the content.

During the treatment phase, the flipped video consisted of a screencast using Doceri software that allowed for screencast projects to be developed and distributed multiple ways to students. ("Doceri - The interactive whiteboard for iPad.", 2015).

The screencast was flexible in that it recorded for video playback lectures, overviews, previews of class content, and demonstrations (Sugar, Brown, & Luterbach, 2010). Anything that could be placed on the computer screen could be combined into a video for playback. The video screencasts for the treatment were uploaded to Canvas, a learning management system. Students viewed these at home, downloaded them at school, or had them airdropped to them via Apple computers. It was essential to have multiple ways of distributing them to students since home internet reliability was an issue.

Table 1 outlines the treatment and nontreatment methodology. Since the three science classes involved in the action research were grouped by math placement rather than by a heterogeneous academic grouping, the study compared the students in classes A, B, and C as an aggregate rather than comparing classes to each other. All classes began with nontreatment, Module 1 and continued with treatment, Module 2.

Table 1
Nontreatment and Treatment Outline

Nontreatment (Traditional)	Treatment (Flipped Classroom)
Class A, B, C <u>Weeks 1 – 4</u> • Module 1: Science Investigations • Use A tool for Storyline Coherence: • Question, Phenomena, Science Practices to Engage in, *Making Sense of It • Homework: *Making sense of it written work.	Class A, B, C <u>Weeks 5 – 8</u> • Module 2: Engineering Investigations • Use A tool for Storyline Coherence: • Question, *Phenomena, Engineering Practices to Engage in, Making Sense of It • Homework: *Phenomena introduced through a video screencast

The only item that changed between the nontreatment and the treatment was the portion that was sent home as homework; this was the flipped part. In the traditional classroom homework was the higher-level application part of the lesson. This often involved thinking critically about the day's lesson. During the treatment, the homework was the flipped. Rather than the homework being a closure to a lesson that required higher order thinking, it was an introduction the next day's lesson in the form of a video. Being an introduction to the next day's lesson, it represented lower level learning.

Timeline for Action Research

My action research project started on Tuesday, October 18; parent and student consent forms were sent home. On Thursday, October 20, the Student Adaptive Learning in Science Questionnaire (SALES survey) was administered to students as a pretest prior to the nontreatment part of the project. The SALES survey was administered again after the nontreatment and at the end of the treatment phase. On October 24, the nontreatment phase began and ran through Wednesday, November 16. During this phase, Student Work Samples, Teacher Observation Field Notes, 3-Minute Student Interviews, and the Student Engagement and Thinking Checklists were used to collect data on a daily basis. The treatment phase began on Monday, November 21 and ran for four weeks, terminating on Wednesday, December 14th. At the end of the treatment phase, the Flipped Classroom Survey and the Focus Group Interviews added to the data collection mix. Table 2 summarizes the general timeline for the action research.

Table 2
Timeline for Action Research

Treatments	Timeline
Pre-Action Research	• Tuesday, October 18: Parent and Student Consent Forms are sent home • Thursday, October 20: Administer SALES questionnaire as pretest
Non-treatment	• Monday, October 24: Begin non-treatment. Collect data. • Wednesday, November 16: End non-treatment
Treatment	• Thursday, November 17: Begin treatment. Continue to collect data. • Wednesday, December 14: End treatment. Administer final data collection.
Post Action Research	• Thursday, December 15: Begin post data analysis

A more detailed description of the timeline can be seen in Appendix A. The tables are divided up into treatment periods and indicate the day, class block, and when instruments were used.

Triangulation Matrix

The following table summarizes the relationship between the questions and the instruments used. The research questions are listed down the first column and the instruments used are listed across the first row of the table. The instruments and questions are then matched up showing attempts at triangulation. All questions are answered with at least three different points of data (Table 3).

Table 3
Data Collection Matrix

RESEARCH QUESTIONS	Student Work	Students Adaptive Learning Engagement in Science (SALES) Questionnaire	Student Unit Feedback Survey	Focus Group Interviews	Student Engagement Checklist	Teacher Observation Field Notes and Engagement	3-Minute Student Interviews	Flipped Classroom Survey
PRIMARY QUESTION: In what ways are student higher order thinking skills impacted by the flipped classroom?	X	X				X	X	
SUB QUESTION 1: To what extent does the flipped classroom impact student engagement?		X	X		X	X		X
SUB QUESTION 2: What perceptions do students have about flipped classroom as compared to the traditional classroom?			X	X				X

Data Collection

The instruments and data collection techniques described in the next section show reliability and validity. Key instruments in each question are used in their entirety, modified, or adapted from previous peer reviewed instruments. Multiple instruments address multiple questions, so triangulation between instruments was possible. Attempts were made to increase accuracy and credibility by triangulating all data. Additionally, the instruments were peer reviewed by colleagues, classmates, and professors.

Data Collection Methods for Primary Question

In what ways were student higher order thinking skills impacted by the flipped classroom? To answer the primary research question, four instruments were used: student work, the 3-Minute Student Interview, teacher observation field notes, and the Students Adaptive Learning Engagement in Science (SALES) survey. These worked together to answer the question.

The student work samples, administered to all students, provided raw quantitative data to compare how scores changed between the nontreatment and treatment phase. Quantitative data from the student work was used to determine the median score on the Making Sense of It assignments for each class (Appendix B). The standard deviation for each class was compared to determine the spread of scores between the nontreatment and treatment. A bar graph of the Making Sense of It assignment scores vs. class study-time was created to determine if there was a correlation between them. Individual students and groups of students were also separated to determine if there were different impacts. The Unpaired t-test determined the significance of the data. The Critical Thinking and Assessment Rubric was developed by the Concordia Middle Science department in 2013 and has been used consistently and reliably for three years (Appendix C).

The 3-Minute Student Interview was administered to one student per class by drawing their name from a container (Appendix D). These same groups of students were then interviewed during the treatment phase. This was done at the end of the period while students began work on their Making Sense of It assignments. The questionnaire was adapted and modified from a questionnaire published in Edutopia that is action research

based (Alber, 2013) and the Look2Learning research form developed by John Antonetti on classroom walkthrough protocols (*Look 2 learning tally sheet*, 2016). Specific questions that address the impact of higher order thinking are: What was the point of today's lesson? Why do you need to know this? How would you use this outside of the classroom? Any changes between the treatment and nontreatment were compared to changes in student work samples. The responses were tabulated, coded for patterns and themes, cross referenced with the student work samples, and then compared to the responses during the treatment.

A third instrument used to determine how achievement or higher order thinking skills were impacted by the flipped classroom was through Teacher Observation Field Notes (Appendix E). The field notes were adapted from two documents and consisted of checklists and narratives: The Look2Learning data collection sheet (*Look 2 learning tally sheet*, 2016) and the Classroom Observation and Analytical Protocol Document (*Inside the classroom observation and analytic protocol*, 2000). A checklist indicated the level of learning demonstrated by the class, general class mastery, appropriate connections made, and types of activities students were doing. Together these indicated the level of critical thinking or achievement that was occurring. This information was then compared to student work, the 3-minute student interviews, and data collected during the nontreatment and treatment period.

Last of all, the SALES survey was used as a predictor of achievement (Appendix F). It has a predictive quality; it correlates with student achievement. Generally, students who score high on the SALES questionnaire are predicted to score high on science

achievement as indicated by the classroom grades (Velayutham, Aldridge, & Fraser, 2011). The results of the SALES survey were compared to the changes in student grades over time to address my primary question.

Data Collection Methods for Sub Question 1

Five instruments were used to answer the question, “What extent does the flipped classroom impact student engagement?” These instruments were: The Student Adaptive Learning Engagement in Science survey (SALES); the Flipped Classroom Survey; Teacher Observation Field Notes; Student Engagement and Thinking Checklist; and the Student Unit Feedback Survey.

The SALES survey was the primary instrument used in answering this question. This questionnaire served as a baseline for comparing the extent of change in student engagement between the traditional classroom and the flipped classroom. The SALES questionnaire was given to all the students in the study three times: before the nontreatment, after the nontreatment, and after the treatment. It was composed of 32 Likert Scale questions grouped into four categories: learning goal orientation - measures the extent that students feel they are participating; self-efficacy - measures a student's confidence and believe that they can do science; task value - measures the extent that student feel value in the subject; and self-regulation - measures students sense of control over their learning (Velayutham, Aldridge, & Fraser, 2011).

The SALES questionnaire used a Likert Scale and is considered interval data. As a result, the mean and the standard deviation were used to describe the scale and help

determine change in student engagement before the nontreatment, after the nontreatment, and at the end of the treatment.

The Flipped Classroom Survey was a second measure of student engagement (Appendix G). This survey was adapted from a survey given to students in three high school classrooms in Canada (Johnson, 2013). It was given to all students at the end of the treatment, and was broken into two categories - perceptions and engagement. Four questions focused on engagement in the traditional classroom and four questions focused on engagement in the flipped classroom. The aggregate of each category was grouped together to find the mean and compared to each other.

A third instrument used to measure student engagement was the Teacher Observation Field Notes. These notes contained a daily checklist of engaging qualities of a classroom derived from The Look2Learning data collection sheet: personal response, clear/modeled expectations, emotional/intellectual safety, learning with others, sense of audience, choice, novelty/variety, and authenticity. The presence of three or more of these activities correlated to engaged learners (*Look 2 learning tally sheet*, 2016). Mode, median, and ranges were used to compare the nontreatment to the treatment.

A fourth instrument used to measure engagement was the Student Engagement and Thinking Checklist (Appendix H). This form was adapted from The Look2Learning data collection sheet (*Look 2 learning tally sheet*, 2016) and the Classroom Observation and Analytical Protocol Document (*Inside the classroom observation and analytic protocol*, 2000). This instrument contained four Likert scale questions that cross referenced with the primary categories on the SALES survey: learning goal orientation,

task value, self-efficacy, and self-regulation. The mean score correlates with the level of engagement. The group and composite mean and standard deviation were compared to the values derived from the SALES survey.

A fifth instrument used was the Student Unit Feedback Survey (Appendix I). Part of the survey contained questions used to ascertain students' feelings about being on task and engaged. This information was compared to data from the Daily Student Engagement and Thinking Checklist.

Data Collection Methods for Sub Question 2

Three instruments were used to answer sub question two, "What perceptions do students have about the flipped classroom as compared to the traditional classroom". The three instruments used were: The Student Unit Feedback Survey, The Focus Group Interview, and the Flipped Classroom Survey.

The Student Unit Feedback Survey primarily measured perceptions. The survey was modified from a feedback survey given to high school students at a Dallas, Texas high school ("Student feedback survey", 2016). The survey has Likert style questions that asks students to rate their perceptions about homework, focus, ability to get help from others, preference watching videos to written homework, level of challenge, and homework completion rates. The survey was administered to all students at the end of the nontreatment and again at the end of the treatment. The mean and standard deviation was calculated for each class.

The second instrument used to measure student perceptions was the Focus Group Interviews (Appendix J). This interview was conducted at the end of the treatment phase

which was at the conclusion of the class action research project. Gender information was recorded to determine any differences in perception, which could then be cross referenced with previous data to explain possible differences. The interviews were recorded digitally. Six students from each class were selected from each class: three male students and three female students with a mix of low, medium, and high students. The interviews consisted of seven key questions that determined the advantages and disadvantages of the flipped classroom and the traditional classroom's that they experienced. Common themes and patterns indicated student preferences.

The third instrument to measure student perceptions was the Flipped Classroom Survey. Part of this survey measured student perceptions about their experience in the traditional classroom compared to the flipped classroom. Eight Likert scale questions focused on student perceptions of the traditional classroom and eight focused on perceptions of the flipped classroom. The mean of the two groups were computed and compared to each other and with the results of other instruments measuring perceptions.

This action research project was approved by the IRB on August 29, 2016. It was exempt from the requirement to be reviewed by the Institutional Review Board (Appendix K).

DATA AND ANALYSIS

Achievement

Achievement levels were assessed by analyzing data generated from student work, teacher field notes, the 3-Minute Student Interviews, and the SALES survey.

Measuring Achievement with Student Work and In-class Work Time

Data suggests that the flipped classroom environment improved student scores on the Making Sense of It assignments and that in part, these improved scores may be a result of increased work time in class ($N=48$).

The percent change on the assignment performance between the traditional classroom and the flipped classroom was +3.91%, ranging from a +18% change to a -8.1% change. Overall thirty-eight students (79%) showed a positive change, two students showed no change in their average score, and eight students showed a negative change. Individual students ranked high, medium, and low were analyzed. Students who were ranked in the bottom fourth of the class all improved their scores with the treatments (Figure 1).

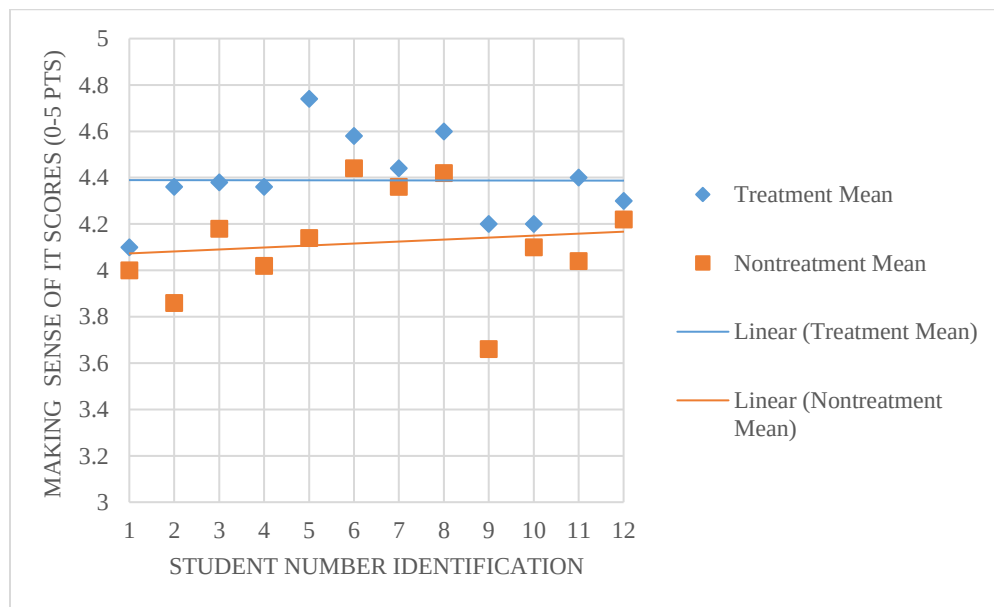


Figure 1. Bottom fourth of students' performance, treatment vs nontreatment, ($N=12$).

The aggregate standard deviation for each of the three classes was tighter during the flipped classroom than during the traditional classroom, with the exception of Class B

where the results were opposite; Figure 2 shows this. The correlation suggests that perhaps the flipped classroom environment, where students could collaborate with peers and the teacher, improved the consistency of their answers on their Making Sense of It assignments. The Unpaired t-test results showed a two –tailed p value of .0033; this is considered very statistically significant. This indicates that the change in treatment, using the flipped classroom model, was impactful on student achievement.

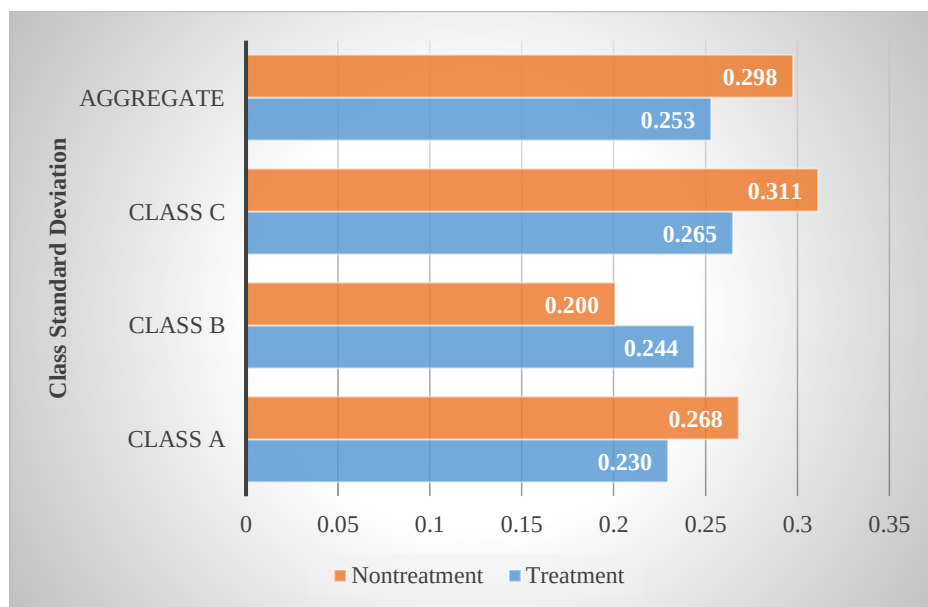


Figure 2. Standard deviation comparison between classes, (N=48).

The data in Figure 3 shows how each class improved their scores on the Making Sense of It assignments between the nontreatment (traditional classroom) to the treatment phase (flipped classroom). It also suggests that increased class work time may also have played a role in improved scores. The average increase in performance was 0.17 points or a 3% overall increase. There appeared to be a positive correlation between time and scores. Average scores increased from 88.0% to 91.0% between the traditional and the

flipped classroom phase possibly because of more time to work on the assignments in class.

During the traditional classroom, the Teacher Observation Field Notes indicated that students had an average of 5.73 minutes to work on the Making Sense of It assignment while during the flipped classroom, students had 12.78 minutes to work on it. Although a 3% increase in average scores seemed minor, it appeared that working on the assignments during class contributed to higher level student responses overall. Perhaps more time to work in class correlated with the tighter spread in the standard deviation during the treatment phase.

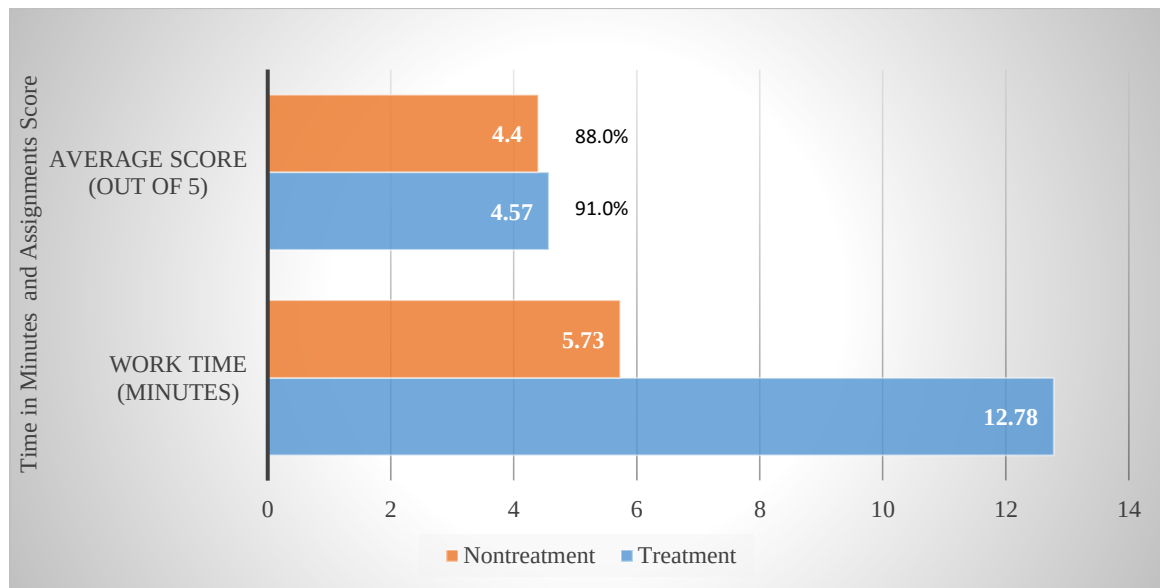


Figure 3. Correlation of work time vs average score, (N=48).

Measuring Achievement Through Student Interviews

Table 4 shows the data collected from student interviews. The interviews helped determine if lesson objectives were learned and the level of learning that had occurred – indicated by the students' ability to connect the learning beyond the lesson. Sixteen students were interviewed – one after each lesson during the treatment and nontreatment -

about the objective of the lesson and its outside connection as a measure of academic achievement between the flipped and non-flipped classroom.

Quantifying the responses to determine if the objective was met was black and white – the student either was able to state the objective or was not. Categorizing the level of connections made was a little more difficult; it involved looking for common characteristics in each student response. High level connections were indicated by a score of 5 on the rubric and were responses that were considered to be beyond the standard. These responses were characterized by depth and a clear connection beyond the classroom: “It [making scribble bots] helps us learn to solve similar problems outside of the classroom. Like...maybe when something electronic breaks or the breaker goes out we can understand how it works. It also helps us work as a team. The reverse engineering part helps us understand how things are.”

Middle level connections were indicated by a score of 4 on the rubric and were responses that were considered to meet the standard. Middle level responses lacked detail but all included a clear connection beyond the classroom: “I know that science does not include a definite process, but includes certain elements like a hypothesis, procedures, analysis, trials...yah. Kind-of like the pinball machine. It reminds me of CSI sort of.”

Low level connections were indicated by a score of 3 on the rubric and were responses that were considered to be below the standard. Low level responses often lacked detail and lacked finding a connection beyond the classroom or school environment: “If I were a scientist, I would need to use knowledge of how to set up an experiment or when I move into high school.”

Table 4
3-Minutes Student Interview Data

	Levels of Students	Number of Students at that Level	Objective of Lesson Communicated (Percent)	Level 5 (High) Connections Beyond Standard	Level 4 (Middle) Connections Meet Standard	Level 3 (Low) Connections Below Standard
Traditional Nontreatment	H	3	93.7	1	10	5
	M	9				
	L	4				
Flipped Treatment	H	3	93.7	4	8	4
	M	9				
	L	4				
The same students were interviewed during the nontreatment and treatment (<i>N</i> =32).						

During the nontreatment, ninety-three percent of the students indicated the objective of the lesson. One of the students interviewed was able to make connections beyond the standard, ten students were able to meet the standard, and five students made connections below the standard. During the treatment phase the same students were interviewed randomly by pulling their names from a jar using the same questions. Similar to the nontreatment, ninety-three percent of the students communicated the objective completely. Four of the students made connections above the standard, eight students met the standard, and four students made connections below the standard. Overall, progression to a higher level was seen during the treatment with the most significant jump from students making connections at the standard to making connections beyond the standard.

The student interview data suggests that the treatment phase had no difference on students' understandings of the objective; however, the data indicates a positive effect on students' abilities to make connections beyond the standard. Perhaps once again this was

due to the fact that students had more time to collaborate and discuss as compared to the nontreatment phase.

Measuring Achievement with Attitude

There should be a strong correlation between attitudes and achievement as determined by the SALES survey which is discussed in length in the next section. Increased attitudes measured by self-efficacy, task-value, self-regulation, and goal orientation should have led to increased scores according to the instrument. Both genders showed increased scores, but only females had an increase in attitude while male's attitude decreased (attitude is discussed in the next section). Figure 4 shows the change in scores by gender on the Making Sense of It assignments and Figure 5 and Figure 6 shows the changes in attitude.

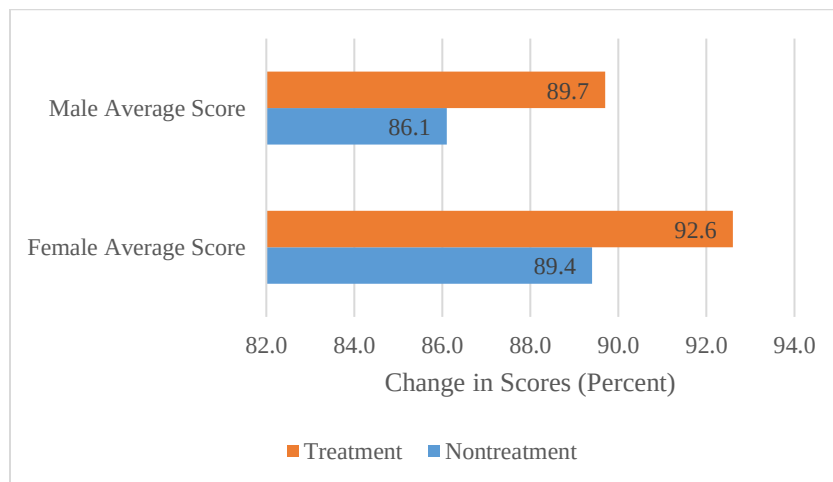


Figure 4. Gender difference in assignment scores, (N=48).

Females increased scores on the Making Sense of It Assignments by two percent between nontreatment (traditional classroom) and the treatment (flipped classroom). Perhaps their scores increased with their rise in confidence levels. Also, during discussion times, the females engaged in more conversation amongst themselves than did the males.

Females also became more confident (self-efficacy), expressed higher value for science (task value), and grew in their sense of control over their learning (self-regulation) throughout the study. However, students felt like they participated less (goal orientation).

Males also improved scores by three percent, but their treatment attitudes were lower across the board than their nontreatment attitudes. Males were overall less confident, showed less value, and felt they had less control over their learning. Interestingly, male participation remained nearly the same across all phases and was still higher than females following the treatment. There was a positive correlation between attitude and achievement for females, but a negative correlation for males. Male participation remained unaffected. Achievement scores increased for both gender during the flipped classroom, but it is not conclusive from this study whether changes in attitude had an effect on the gains in achievement.

Student Engagement (Attitude)

The extent that the flipped classroom impacted student engagement utilized five instruments: the SALES survey, the Student Unit Feedback Survey, the Flipped Classroom Survey, Teacher Observation Field notes, and the Student Engagement and Thinking Checklist helped answer the question.

Measure Engagement (Attitude) with the SALES Survey

The results of the SALES survey - the Student Adaptive Learning Engagement in Science survey - were quite intriguing. Comparing all student responses across all three testing sessions indicated that students consistently had higher engagement levels prior to

the treatment (traditional classroom), but dropped during the treatment (flipped classroom). See Figure 5. This was not expected.

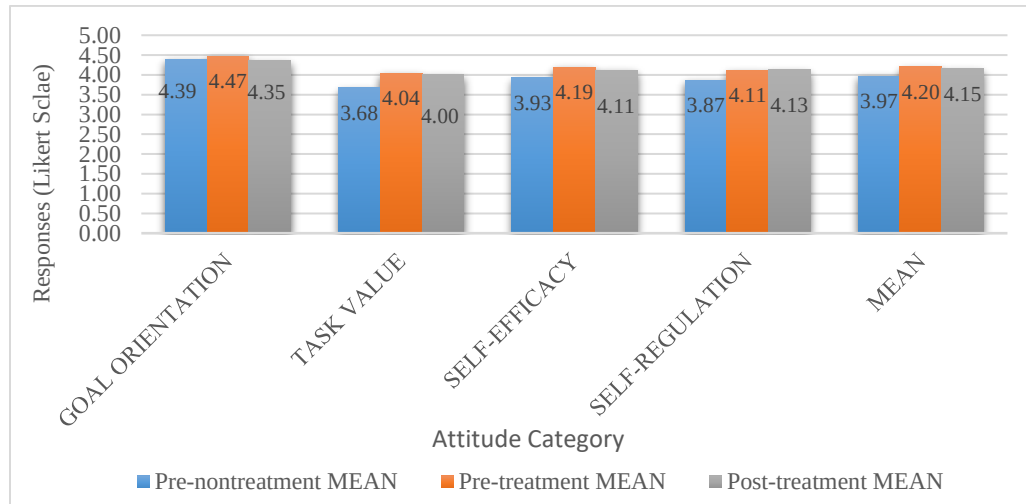


Figure 5. Attitudes: category comparison in SALES survey, (N=48).

Extrapolating the data by gender, females showed an increase in engagement while male engagement levels dropped, see Figure 6. When comparing male to female responses across all three surveys, females generally showed an increase in Task Value, Self-efficacy, and Self-regulation after each survey with a drop in Goal Orientation. Males showed an improved attitude across all areas from the pre-nontreatment to the pretreatment. The posttreatment results indicated that their attitudes reverted back to nearly the same or below their initial attitudes. So, the flipped classroom increased the overall attitude for females and it had little effect on male attitude. As mentioned before, increased attitudes for females may have resulted in their rising confidence levels and their increased collaboration time during the treatment. The novelty may have decreased as time went on for the males. However, this is more opinion than fact.

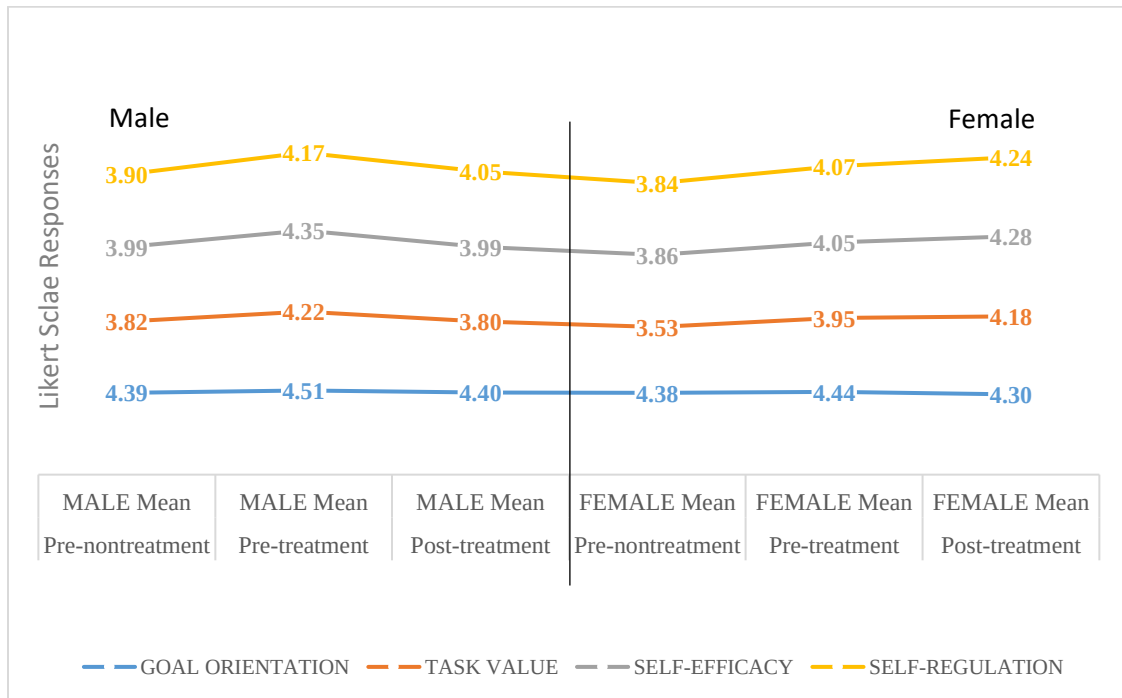


Figure 6. Change in gender attitudes toward science based on multiple surveys, (N=48).

Measure Engagement (Attitude) with Student Reflection

Students were asked to rate their level of focus or engagement on the Student Unit Feedback Survey and Daily Student Engagement and Thinking Checklist. Figure 7 shows this relationship.

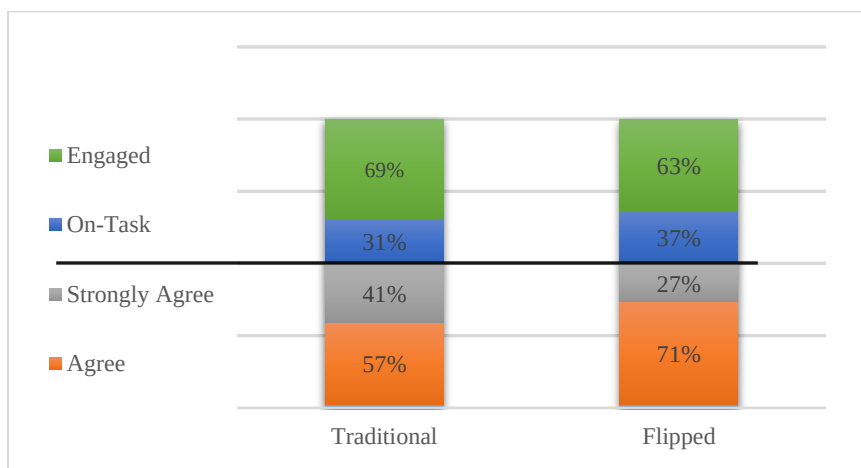


Figure 7. Feelings of engagement, self-reflection, (N=48).

More students felt engaged and strongly agreed that they were on-task during the traditional classroom (nontreatment) than they did in the flipped classroom (treatment). This agrees with the overall results of the SALES survey in which overall all, students were less engaged. Gender data was not collected for this particular question.

Four more questions on the daily Student Engagement and Thinking Checklist measured students Learning Goal Orientation, Task Value, Self-Efficacy, and Self-Regulation. These cross-reference with the primary categories on the SALES survey. Similar to the results in the SALES survey, students indicated overall, they were more engaged during the traditional than the flipped classroom, see Figure 8.

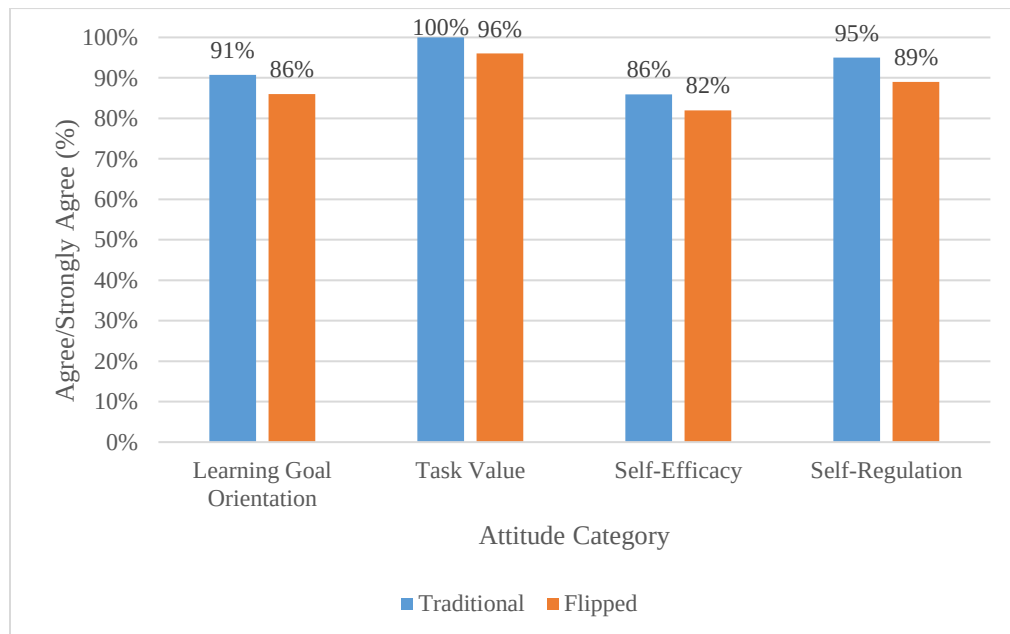


Figure 8. Percent of students that strongly agree/agree about being engaged, ($N=48$).

Measure Engagement (Attitude) Using Teacher Observations

Teacher Observation Field Notes recorded the presence of the key elements of personal response, clear/modeled expectations, emotional/intellectual safety, learning with others, sense of audience, choice, novelty/variety, and authenticity. Table 5 shows

that all of the lessons in both the traditional and flipped classroom contained four of these elements one hundred percent of the time. Since the presence of three or more of these activities in a lesson correlates to engaged learners, both units provided the successful elements for engagement. This supports the study by providing evidence that the classroom learning environments during the nontreatment and treatment were equally organized in such a way to provide equal levels of engagement. Although there were some differences in the elements, all of the top four elements were present all of the time in both the traditional and flipped learning environments.

Table 5

Look2Learning Key Elements for Engaging Classrooms

Frequency of Key Elements in Traditional and Flipped Classroom		
Key Element	Traditional (4 weeks)	Flipped (4 weeks)
Clear Modeled Expectations	100%	100%
Learning with Others	100%	100%
Novelty/Variety	100%	100%
Authenticity	100%	100%
Choice	71%	80%
Emotional/Intellectual Safety	50%	57%
Sense of Audience	56%	50%
Personal Response	7%	7%
<i>Presence of 3 or more of these correlate to engaged learning (N=48).</i>		

Perceptions

Data from the Student Unit Feedback Survey, the Focus Group Interview, and the Flipped Classroom Survey was used to measure perceptions.

Measure Perceptions About Preference

The Flipped Classroom Survey results indicated that students preferred the flipped classroom over the traditional classroom. Preference for the flipped classroom or traditional classroom was measured in two different ways. Seven questions were written using a Likert scale format would show preference for the flipped classroom and seven questions were written in a manner that would show a preference for the traditional classroom. The mean from these two groups is indicated in Figure 9 below. The spread indicated by the Likert responses was 1.15 in favor of the flipped classroom on a scale of one to five. Second, two individual question were asked to measure how students perceived the required task associated with the two methods of instruction. Students indicated a 2.45 frustration level when completing videos with the flipped classroom and a 3.14 frustration level in completing written homework with the traditional classroom. These results are supportive of each other. There was a higher overall preference for the flipped classroom and a lower level of frustration. Students favored the video as homework over the traditional written homework.

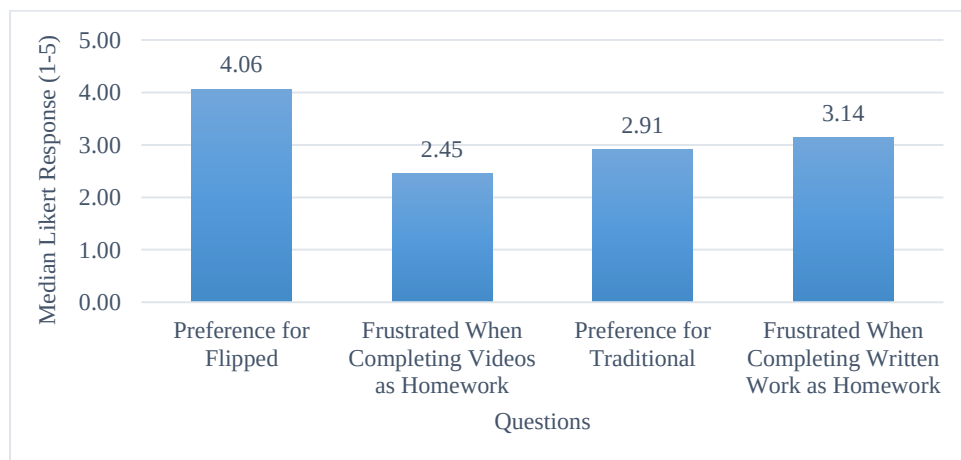


Figure 9. Preference for the flipped and traditional classroom, (N=48).

A stand-alone question asked students if they would recommend the traditional model of learning or the flipped model learning to a friend. Nineteen percent indicated they would agree to/or strongly agree to recommend the traditional model and sixty-four percent indicated they would agree to/or strongly agree to recommend the flipped model to a friend. The flipped classroom model was the clear preference.

Focus Group Interviews were conducted at the conclusion of the study where 18 students were interviewed – six students from each class. Results showed that fourteen students favored the flipped classroom while four students favored the traditional classroom. Eight boys and six girls recommended the flipped classroom over the traditional and one boy and three girls recommended the traditional classroom over the flipped classroom. Figure 10 summarized the results from the interviews; seventy-eight percent favored the flipped classroom while twenty-two percent preferred the traditional classroom.

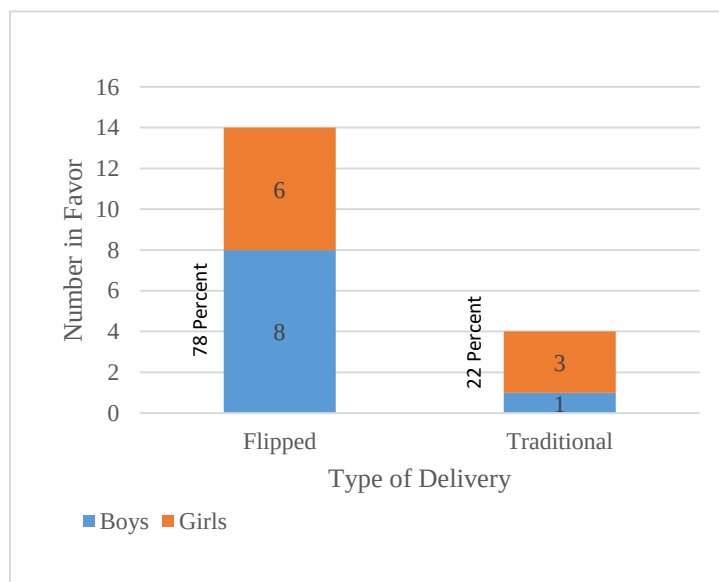


Figure 10. Preference for flipped or traditional from post interview data, (N=18).

Measure Perceptions of Advantages and Disadvantages of Flipped Classroom

Students had various opinions on the advantages and disadvantages of the flipped classroom as is indicated from the Focus Group Interviews that followed the flipped classroom. Table 6 contains comments where two or more students made similar comments, but only one of the student's quotes were written down.

Table 6
Focus Group Interview Comments

Student Perceptions About Advantages and Disadvantages of the Flipped Classroom	
Advantages	Disadvantages
"...stuff is explained before so you have more time to work on labs and everything in class..."	"It drained my computer from downloading."
"It gets you excited about what you are going to do the next day."	"The videos were not graded so more students faithfully completed the traditional homework."
"I think they were more engaging"	"The traditional method teaches you more than the videos."
"I had more time in class to get my work done."	"Sometimes the videos did not load properly and were lagging."
"In the flipped classroom you could just learn at your own pace and it is really good for visual learners."	"If you don't understand the video the first time what were the odds of you understanding it the second time?"
"We were held accountable because we were expected to begin the work (discussed on the videos) right when we walked in the door."	"At times the internet did not work."
"Kids like watching videos more than writing. It is more interesting..."	"Sometimes the audio would not match up and I would get confused."

N=18

Common themes emerged from the student responses in Table 6. Key themes that favored the flipped classroom included the following paraphrased responses: video was more engaging and exciting; it allowed for more worktime; it allowed for learning at one's own pace; it made students more accountable for learning the next day. Key themes on the disadvantages of the flipped classroom included: it was a drain on the computer; the lack of assigning a grade to the video made it less important; it teaches less than the traditional; downloading videos was a problem outside of school; it only provided for one

mode of learning. Many of the disadvantages dealt with technology issues while the majority of the advantages of the flipped classroom related to increased feeling of engagement and interest.

Another survey was administered to look at how students perceived the traditional and flipped classrooms. The Pre-Student Unit Feedback Survey collected Likert-style questions about student perceptions following the traditional classroom. One of the stand-alone question showed a near-equal preference for the method of completing homework, $N=48$. Ninety-one percent of the students were satisfied with the traditional method of doing homework, with a weighted Likert-style average of 3.91 out of a five-point scale. Eighty-nine percent of the students were satisfied with the flipped classroom where videos were sent home as homework, with a weighted Likert-style average of 3.82. This data contrasts with all other data showing which showed that students preferred the video format over the written format.

Looking over student written responses from this survey, common themes emerged from students who were satisfied with the traditional method of work. Nineteen percent wrote comments that they were satisfied because they were used to doing the traditional style of homework. One student wrote, "In most of my other classes, I use the traditional learning model to complete homework, so I am used to doing the traditional model. It works." Twelve percent of the students mentioned in their comments that doing traditional homework provided a deeper understanding. One student wrote, "Because it doesn't just make us memorize terms and things, it forces us to have a deeper understanding of the subject."

The Post Student Unit Feedback Survey – administered after the flipped classroom - also revealed some common themes about student perceptions about watching videos at home. Looking over student written responses, 18% of the students wrote about how they felt they had more time to work in class. One student wrote, “Watching the videos gave us more time in class to work, so I felt more productive in class.” Twenty-percent of the students wrote that the flipped classroom was easier because the videos required less time and 13% of the students commented that watching videos was more engaging.

INTERPRETATION AND CONCLUSION

I set out on this action research to determine how the flipped classroom, when measured against the traditional classroom, would impact student achievement – primarily higher-level learning - student engagement (attitude), and student perceptions. I discovered that the flipped classroom had a positive impact on achievement, a mixed impact on engagement and attitude, and was perceived as a favorable method of instruction for most students.

Impact on Student Achievement

The flipped classroom had a positive impact on student achievement. Scores were slightly better using the flipped model of learning over the traditional model, although the increase in scores was only about two percent, 79% percent of the students had an average increase in their overall scores between the traditional classroom and the flipped classroom, with some students making +18% gains. All students identified in the bottom third across the three classes under study increased their scores between the tradition

classroom (nontreatment) and the flipped classroom (treatment) indicating that the flipped classroom was beneficial for all of them. The lower achieving students may have benefitted from more collaboration time and teacher contact time, improving their scores. Their increased confidence levels along with familiarity with the routine may have also impacted their improved scores.

A positive correlation between academic achievement – measured by student scores on their Making Sense of It assignments – and time spent working on assignments in class was apparent. During the flipped classroom, students were introduced to the next day's lesson with a video the night before. When students arrived for class, a quick review was all that was needed before students began work, which allowed for more time to work on the application assignments during class. This increased worked time allowed for increased collaboration time to share ideas with each other and more time for teacher feedback, resulting in improved overall scores.

Student Engagement

Student engagement, measured by changes in student attitudes, showed a slight drop in overall engagement levels. The SALES survey showed a decrease in attitudes toward science across all three combined classes. The Student Unit Feedback Survey also showed students felt less engaged during the treatment. One unexpected finding occurred: when data from the SALES survey was extrapolated by gender, female students showed an increase in their attitude throughout the study while males showed a slight decrease or little change. One explanation is that as females continued investigations, their confidence in their ability to do science also increased. One female student mentioned

that she preferred the flipped classroom because “we get more time to work on our labs instead of the teacher taking 20 minutes to talk about what we are doing”. Perhaps this increased work time improved this students’ confidence and performance.

Student Perceptions

Student perceptions about the flipped classroom showed students favored the flipped classroom over the traditional model of learning by a large margin. The results of the Student Unit Feedback Survey indicated 64% recommended the flipped classroom over the 19% that recommended the traditional classroom. The Flipped Classroom Survey compared preference with frustration levels. More students preferred the flipped classroom than the traditional classroom. More students also indicated higher frustration levels with written work as homework than watching videos as homework. Clearly the flipped classroom led to lower frustration levels.

Interviews indicated that students perceived more advantages for the flipped classroom than disadvantages. The majority of the advantages were related to increased feelings of interest and fun. The students also perceived the flipped environment to be a place where they had more time to work on homework and get help. Most of the disadvantages focused on technology issues in viewing and downloading the videos; the Internet in the country of study was noted to be frustrating at times and slow download speeds at home added to the frustration for students.

Impact of Research and its Implications

This research impacts my classroom in multiple ways. The positive impact of the flipped classroom on achievement is worth exploring more. I had some students with

18% gains during the flipped classroom, but other students dropped by eight percent. Students identified in the bottom twenty-five percent all improved their scores between the nontreatment and the treatment. It appeared that the flipped classroom would be a successful way of differentiating in the classroom for the lower performing student. The research also showed a correlation between academic achievement on the written work and increased work time in class. Students that had more class time to work on the written work usually finished it in class and were able to get extra assistance and help from peers and the teacher. In addition to this, I was able to work one-on-one with students more and discuss the assignments with them during this extra time; this may have factored in to the improved scores with the bottom fourth of my students. As a teacher, it was powerful to get that one-on-one time with students. If not for this reason alone, the flipped classroom in some form or other, will remain a key component of my classroom practice.

As a teacher, I have always assumed that higher engagement levels lead to higher academic gains. Both of these units were constructed in ways that encouraged engagement so it was not surprising to see average scores ranging for 86% to 92% in the both the nontreatment (traditional) and treatment (flipped) phases.

I was also intrigued about how - although the overall classes showed decreased levels of engagement between the traditional classroom and the flipped classroom - females showed increased levels of engagement and males showed decreased levels. One possible reason already suggested was that as time went on, female confidence levels in doing science increased throughout the study. As a teacher, I need to make sure that I am

delivering a curriculum where both genders can succeed. Male students already had a high level of confidence – starting at higher levels than did the females - so although they showed decreased levels of engagement, they were in fact still engaged.

Implementing the flipped classroom will require additional considerations. One written comment that was made multiple times and verbally expressed was that although the flipped classroom made students accountable for being ready the next day, it was not associated with a grade. In the country of this study, Internet connectivity was a problem, so I chose to use a screencast for the videos. The disadvantage of this was that I could not use any of the available commercially flipped classroom learning management systems because of government blocks. These often have a way to imbed quiz questions in the videos along with the ability of the teacher to monitor student responses and viewing habits. Additionally, Google and YouTube are also blocked outside of the school and only accessible with a virtual private network, which the school cannot require students to have since it is technically illegal. Although I had students write down key understandings from the videos in their homework, their notes were not graded. Perhaps this lead to a feeling of decreased engagement by some students. Future flipped videos will have to have some grade attached to the video to encourage those students that are externally motivated to take the video homework more seriously.

The flipped classroom also requires a time commitment and a high level of organization to be implemented successfully. Each video took about 30 minutes to record and upload into the student management system. These videos also needed to be recorded

in advance so students could watch them at their own pace, especially when students were absent or needed some in advance due to planned absences.

A final implication of this study is its applicability to our science curriculum. My colleagues are interested in the results of this study as we focus on increasing engagement with hands-on activities. I believe this flipped classroom model may be a solution to providing more worktime during class and less teacher talk time.

Connection to Other Research Findings

My research findings build upon other research in multiple ways. Prior research has shown improvements in achievement, attitude and engagement over the traditional classroom, although some studies note the benefits are not significant.

Research supports my primary research question concerning the impacts of the flipped classroom on thinking and achievement. In previous studies teachers reported that flipped learning showed increased scores 67% of the time. (*Info-graphic on teacher and student engagement*, 2012). Byron High School noted a 10% gain in student math scores after a year of learning in a flipped classroom (*Flipped learning model increases student engagement and performance*, 2013). Similarly, the results of this study showed that 79% of the students increased their scores.

In addition to supporting general academic gains, previous research also indicated that the flipped classroom positively impacts the academics of lower performing students. Villanova University reported that the flipped classroom could help struggling students where 10% gains were noted among students in the bottom third of the class (*Flipped learning model increases student engagement and performance*, 2013). The bottom 25%

of the students in this study showed all improved scores. The average gain was 7%.

Furthermore, in 2013, a study conducted by a student at Montana State University on her High School Environmental Systems and Society class, showed lower performing students saw the greatest gains in grades. She attributed this to the one-on-one interaction with teachers and increased work time (Marlowe, 2012). This study also found this to be the case where increasing the work time in class contributed to higher levels of achievement on student written assignments, possibly because of the increased one-on-one interaction with the teacher and peers.

Previous research supports my second research question concerning the impacts of the flipped classroom on attitude. Previous studies indicated that attitudes improved with the flipped classroom. The survey conducted by the Flipped Learning Network revealed that teachers reported that 80% of their student's attitudes improved with the flipped classroom (*Info-graphic on teacher and student engagement*, 2012). In this study, while attitudes improved for females across all treatments, it dropped slightly for males. Possibly this is supported by research done in a university biology class in the United States where the flipped classroom was compared to an equally engaging classroom where the BSCS 5E Instructional Model was the method of instruction (Bybee, 2015). It was discovered that change in learning and engagement levels was not significant due to the engaging nature of both delivery methods (Jensen, Kummer & Godoy, 2015). The 4-year study at Harvey Mudd College in California concluded no significant gains in attitudes were found due to similar engaging levels of the flipped classroom and their interactive lectures (Yong, Levy & Lape, 2015). Similarly, the nontreatment and

treatment in this study were noted as both having the necessary elements of engagement. This suggests that the flipped classroom had similar results to non-flipped, but engaging classrooms.

Previous research also supports my findings from my third research question about perceptions of the flipped classroom. Students in Okanagan, Canada, where 84% said they benefited from flipped math classrooms and eighty-five percent of the students agreed/or strongly agreed that the flipped classroom increased students' opportunities to communicate (Johnson, 2013). In this study, 78% of the students favored the flipped classroom over the traditional classroom. Common themes from written comments noted that students felt more engaged and they felt the extra time to work in class was beneficial to their learning because they could get more help.

This action research project indeed found many similarities to research findings discussed in the literature review about the flipped classroom. The previous connections show a few of these connections and is not meant to be all encompassing. Its intention was to show that the action research conducted for this paper had similar findings to other research studies involving the flipped classroom.

VALUE

The experience in doing this classroom research project has been challenging and rewarding. I have learned much about the action research process, data analysis, best use of class time, and how best to maximize student learning and engagement. Additionally, I have identified further areas to research.

Impact on Professional Growth

The action research process was a huge undertaking. Teacher reflection has been a common practice that has occurred throughout my teaching career, whether it be reflecting on a lesson, discipline interventions, assessment reviews, differentiation techniques, or other professional goals. However, my past experiences with reflection has often been over short periods of time, then I moved on. This action research project involved a year of planning, an in-depth literature review, data collection, data analysis, peer review, and a substantial amount of time putting the pieces together in a concise document to communicate my findings. Undertaking this process has made me appreciate the multitude of research currently out there.

My skill at data collection and analysis improved throughout the process. The most difficult part was finding instruments that adequately measured the questions. The literature review helped find reliable instruments, but not all of the instruments fit with what I was really wanting to unearth. As a result, many of the instruments were modified or created by me to suit my specific purpose. If I were to do this again, data collection instruments would become more concise and simplified. I collected much more data than I actually would have needed to support my questions. I would use less instruments while still ensuring triangulation.

Data analysis was not a task that could be completed quickly, nor were the results always clear. Often the results lead to new questions, that lead to sorting through the data once again; however, I did find satisfaction when my triangulated data supported findings from other instruments.

One of the most prevalent outcomes from this action research was its impact on my students and my teaching. Differentiation is a growing practice at our school and I believe I have found a way to differentiate instruction that can lead to increased learning for many of my students, especially those that are lower performing. I found satisfaction in having more time in class for one-on-one or small group instruction. Increased class time to assess my students learning and redirect them before they left class was extremely impactful; my students felt they understood the material better and I had a better understanding about their mastery levels. I believe the time it took to create the videos was worth it. On average, it took about 30 minutes to create each flipped video, but the 10 minutes of extra class time that was made available to focus on student learning was well worth it.

Moving forward, I would like to continue to tweak the flipped classroom model of instruction. In the immediate future if I continue the current method, I see myself flipping certain lessons more than others. Next year major labs and project introductions will be flipped so more class time is available for hands-on learning, application, and collaboration. I will also teach the entire “Thinking Like a Scientist” Unit using the flipped model, rather than just the part used in this project. Last of all, I need to determine a better method of ensuring my students are watching the flipped videos. This may include a quick assessment at the beginning of class to improve their accountability.

I chose the screencast as the mode of delivery because of poor internet quality outside of school; however, I would like to explore other delivery methods or possibly other ways of flipping the classroom that were discussed in my literature review. I would

also like examine how the medium of delivery will affect engagement and understanding. Perhaps instead of videos I might include some “playtime” with some simulations as an introduction to the next day’s lesson – an idea suggested by some of my students.

Finally, this process will impact my science department at school. The results have already been shared with all interested parties. There is a high level of interest in looking deeper into the flipped learning model by my colleagues in other disciplines too. Most importantly, flipped learning will become an additional method – among many – to maximize learning among students at our school.

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APPENDICES

APPENDIX A
TIMELINE FOR ACTION RESEARCH

Timeline prior to action research

Prior to Action Research		
Week 0 (Week beginning 10/17/2016)		
Day	Block	Instruments
Monday - Wednesday		Gather all materials and instruments. Introduce students to the study. Show them the flipped classroom video. Gather permission forms and place in file
Thursday	A, B	Student Adaptive Learning in Science Questionnaire (SALES)
Friday	C	Repeat previous day

Timeline for nontreatment weeks 1-4

Timeline for Non-treatment: Traditional Classroom (Weeks 1-4)		
Week 1 (Week beginning 10/24/2016)		
Day	Block	Instruments
Monday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Tuesday	C	Repeat previous day
Wednesday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Thursday	C	Repeat previous day
Friday	A, B	Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Week 2 (Week beginning 10/31/2016)		
Day	Block	Instruments
Monday	C	Repeat previous day
Tuesday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Wednesday	C	Repeat previous day
Thursday	A, B	Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Friday	C	Repeat previous day
Week 3 (Week beginning 11/07/2016)		
Day	Block	Instruments
Monday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Tuesday	C	Repeat previous day
Wednesday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Thursday	C	Repeat previous day
Friday	A, B	Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Week 4 (Week beginning 11/14/2016)		
Day	Block	Instruments
Monday	C	Repeat previous day
Tuesday	A, B	Student Unit Feedback Survey , Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist, SALES questionnaire
Wednesday	C	Repeat previous day
Thursday	A, B	Parent/Teacher Student Conference Day – No School Talk to parents about the treatment
Friday	C	Repeat previous day

Timeline for treatment weeks 5-9

Timeline for Treatment: Flipped Classroom (Weeks 5-8)		
Week 5 (Week beginning 11/21/2016)		
Day	Block	Instruments
Monday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Tuesday	C	Repeat previous day
Wednesday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Thursday	C	Repeat previous day
Friday	A, B	Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Week 6 (Week beginning 11/28/2016)		
Day	Block	Instruments
Monday	C	Repeat previous day
Tuesday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Wednesday	C	Repeat previous day
Thursday	A, B	Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Friday	C	Repeat previous day
Week 7 (Week beginning 12/05/2016)		
Day	Block	Instruments
Monday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Tuesday	C	Repeat previous day
Wednesday	A, B	Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Thursday	C	Repeat previous day
Friday	A, B	Teacher Engagement Checklist, Student Work Samples; Teacher Observation Field Notes; 3-Minute Individual Interviews, Student Engagement Checklist.
Week 8 (Week beginning 12/12/2016)		
Day	Block	Instruments
Monday	C	Repeat previous day
Tuesday	A, B	Teacher Engagement Checklist, Student Adaptive Learning in Science Questionnaire (SALES); Student Focus Group Interview
Wednesday	C	Repeat previous day
Thursday	A, B, C	Flipped Classroom Survey, Student Unit Feedback Survey
Post Action Research: Conclusion and Data Analysis		
Week 9 (Week beginning 12/19/2016)		

APPENDIX B

MAKING SENSE OF IT ASSIGNMENT SAMPLE

MAKING SENSE OF IT: LESSON 10

Name _____ Period ____

- Compare and contrast the Apollo 13 problem to the Saving Freddie problem (Focus on the criteria and constraints). Use a graphic organizer to compare and contrast.
- Explain a problem you have had to solve before. (What were the criteria for success and what were the constraints?)

Compare and Contrast Apollo 13 and Saving Freddie Problem	
Apollo 13	Saving Freddie
Define the Problem	Define the Problem
Similarities Between Problems	
Define the Criteria	Define the Criteria
Similarities Between Criteria	
Define the Constraints	Define the Constraints
Similarities Between Constraints	
Explain a problem you have had to solve before. What were its criteria, constraints, and your solution? Use a graphic organizer to help us visualize this.	

APPENDIX C

CONCORDIA MS HIGHER ORDER THINKING RUBRIC

Making Sense of It! – Reflection, application, real-world connections

LEVEL 5 (Exceeding Standard)

I can reflect exemplary with details and make connections to the real world using scientific understanding. My work shows evidence of higher order thinking and evidence of impressive, in-depth connections. I can apply my knowledge to new ideas in ways that show understanding. I can use detailed and labeled drawings or webs to show clear connections.

LEVEL 4 (Met Standard)

I can reflect proficiently with some details and make connections to the real world using scientific understanding. My work shows evidence of higher order thinking and evidence of many well, explained connections. I can apply my knowledge to new ideas in ways that show some understanding. I can use drawings or webs to show connections. Sometimes my drawing or explanations lack clarity or depth.

LEVEL 3 (Basic, Not Yet Met)

I can reflect at a basic level and show some connections, but with limited evidence or elaboration, connections, extension, higher-order thinking and/or reflection about the subject. Illustrations and webs may not always show clear connections.

LEVEL 2 (Below Basic, Not Yet Met)

I can reflect at a below basic level. I show limited evidence of elaboration, connections, extension, higher-order thinking about the subject. Illustrations and webs most often lack detail and clarity if even used.

LEVEL 1 (Incomplete)

Insufficient data. Skills not yet met or demonstrated.

Your Score:

Comments:

APPENDIX D

3-MINUTE DAILY STUDENT INTERVIEW

Participation in this research is voluntary and participation or non-participation will not affect a student's grade or class standing in anyway.

What was the point of today's lesson? - Has the objective been clearly communicated to the learners? __Yes __No
Why do you need to know this?
How would you use this outside of the classroom? - Appropriate connections were made to other areas of science, to other disciplines, and/or to real-world contexts. 1 - 2 - 3 - 4 - 5
Explain to me what you are supposed to do on this assignment?
What level of understanding do you think you will achieve? Explain.
What questions do you still have that I should have asked you?

Key: **Independence** determined by the observation that all students in the group believe they can or have performed the assignment without the need of other's help.

Dependence determined by the observation that some students in the group felt they were unclear about parts of the assignment.

Duplicated and adapted from "Five Powerful Questions Teachers Can Ask Students" -

<http://www.edutopia.org/blog/five-powerful-questions-teachers-ask-students-rebecca-alber>

APPENDIX E

DAILY TEACHER OBSERVATION FIELD NOTES

Teacher Observation Field Notes (Daily) Block_____ Date_____

Has the objective been clearly communicated to the learners? ____ Yes ____ No

What was the thinking level?

__Low (Knowledge/Comprehension) __Middle (Application/Analysis) __High (Synthesis/Evaluation)

What was the general mastery level of the students at the end of the period?

1 - 2 - 3 - 4 - 5

Appropriate connections were made to other areas of science, to other disciplines, and/or to real-world contexts. 1 - 2 - 3 - 4 - 5

What were the students doing in the classroom today?

____Introduction ____Anticipatory Set

Concept Development

____Listening

____Reading

____Worksheet

____Writing

____Discussion

____Hands-On/Manipulatives

____Similarities and Differences

____Summarizing/Note-Taking

____Reinforcing Effort/Providing Recognition

____Nonlinguistic Representations

____Generating and Testing Hypotheses

Concept Attainment

____Guided Practice ____Closure ____Independent Practice

Assessment

____Of Learning ____For Learning

Notes

SUB QUESTION 1: To what extent does the flipped classroom impact student engagement?**Does the work assigned to students incorporate engaging qualities?**

☐ Personal Response	☐ Sense of Audience
☐ Clear/Modeled Expectations	☐ Choice
☐ Emotional/Intellectual Safety	☐ Novelty/Variety
☐ Learning With Others	☐ Authenticity

What is the engagement level of the classroom? ☐ Engaged ☐ On-Task ☐ Off-Task**How were the students interacting?**

Interaction with visual models

☐ Yes ☐ No

Interaction with learning tools

☐ Yes ☐ NoAdapted from:

Look2Learning: <http://images.pcmac.org/Uploads/MeadeCounty/MeadeCounty/SubDepartments/DocumentsSubCategories/Documents/E1.3.a%20L2L%20-%20Tally%20Sheet.pdf>; Horizon Research, Inc. Inside the Classroom: Observation and Analytic Protocol – “Inside the Classroom Observation and Analytic Protocol”

APPENDIX F
STUDENTS' ADAPTIVE LEARNING ENGAGEMENT IN SCIENCE
QUESTIONNAIRE (SALES)

Participation in this research is voluntary and participation or non-participation will not affect a student's grade or class standing in anyway.

Appendix. Students' Adaptive Learning Engagement in Science Questionnaire

Directions for Students

Here are some statements about you as a student in this class. Please read each statement carefully. Circle the number that best describes what you think about these statements.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

For each statement, draw a circle around

- 1 if you *Strongly disagree* with the statement
- 2 if you *Disagree* with the statement
- 3 if you *Are not sure* about the statement
- 4 if you *Agree* with the statement
- 5 if you *Strongly agree* with the statement

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another. Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Learning goal orientation	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
<i>In this science class ...</i>					
1. One of my goals is to learn as much as I can.	1	2	3	4	5
2. One of my goals is to learn new science contents.	1	2	3	4	5
3. One of my goals is to master new science skills.	1	2	3	4	5
4. It is important that I understand my work.	1	2	3	4	5
5. It is important for me to learn the science content that is taught.	1	2	3	4	5
6. It is important to me that I improve my science skills.	1	2	3	4	5
7. It is important that I understand what is being taught to me.	1	2	3	4	5
8. Understanding science ideas is important to me.	1	2	3	4	5

Page 2: Participation in this research is voluntary and participation or non-participation will not affect a student's grade or class standing in anyway.

Task value	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
<i>In this science class ...</i>					
9. What I learn can be used in my daily life.	1	2	3	4	5
10. What I learn is interesting.	1	2	3	4	5
11. What I learn is useful for me to know.	1	2	3	4	5
12. What I learn is helpful to me.	1	2	3	4	5
13. What I learn is relevant to me.	1	2	3	4	5
14. What I learn is of practical value.	1	2	3	4	5
15. What I learn satisfies my curiosity.	1	2	3	4	5
16. What I learn encourages me to think.	1	2	3	4	5
Self-efficacy	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
<i>In this science class ...</i>					
17. I can master the skills that are taught.	1	2	3	4	5
18. I can figure out how to do difficult work.	1	2	3	4	5
19. Even if the science work is hard, I can learn it.	1	2	3	4	5
20. I can complete difficult work if I try.	1	2	3	4	5
21. I will receive good grades.	1	2	3	4	5
22. I can learn the work we do.	1	2	3	4	5
23. I can understand the contents taught.	1	2	3	4	5
24. I am good at this subject.	1	2	3	4	5
Self-regulation	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
<i>In this science class ...</i>					
25. Even when tasks are uninteresting, I keep working.	1	2	3	4	5
26. I work hard even if I do not like what I am doing.	1	2	3	4	5
27. I continue working even if there are better things to do.	1	2	3	4	5
28. I concentrate so that I will not miss important points.	1	2	3	4	5
29. I finish my work and assignments on time.	1	2	3	4	5
30. I do not give up even when the work is difficult.	1	2	3	4	5
31. I concentrate in class.	1	2	3	4	5
32. I keep working until I finish what I am supposed to do.	1	2	3	4	5

Velayutham, S., Aldridge, J., & Fraser, B. (2011). Development and Validation of an Instrument to Measure Students' Motivation and Self-Regulation in Science Learning. *International Journal Of Science Education*

APPENDIX G
FLIPPED CLASSROOM SURVEY

Flipped Classroom Survey

Participation in this research is voluntary and participation or non-participation will not affect a student's grade or class standing in anyway.

Here are some question about you as a student in class. Please read each statement carefully. Circle the number that best describes what you think about these statements.

There are now "right" or "wrong" answers. Your opinion is what is wanted. For each statement, click

1 = if you **STRONGLY DISAGREE** with the statement.

2 = if you **DISAGREE** with the statement

3 = if you **ARE NOT SURE** about the statement

4= if you **AGREE** with the statement

5= if you **STRONGLY AGREE** with the statement

Some questions ask you to explain "why" you answered a question they way you did. Please answer the questions truthfully according to your opinion.

Be sure to answer all questions. You may go back and change your answers at any time before you submit. Some statements are similar to each other. Do not worry if some statements are similar. Just simply give your opinion.

1. The flipped classroom model makes better use of my class time.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

2. Why did you answer the question above as you did?

3. I would rather watch the videos at home as homework to prepare for the next day and allow more class time to work on written work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

4. Why did you answer the question above as you did?

5. The Flipped Classroom gives me enough opportunities to communicate with other students on homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

6. Why did you answer the question above as you did?

7. Video homework is easier to understand than my written homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

8. Why did you answer the question above as you did?

9. I get frustrated at home when I have to watch videos as homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

10. Why did you answer the question above as you did?

11. I like how the flipped classroom allows me to understand concepts at my own pace. For example, I like how I can pause and review video concepts when I want to.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

12. Why did you answer the question above as you did?

Adapted from: Johnson, G. (2013). Student perceptions of the Flipped Classroom. *University of British Columbia*, 90-92. <http://dx.doi.org/10.14288/1.0073641>

13. I feel I am prepared for the next day when I watch the videos as homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

14. Why did you answer the question above as you did?

15. I would recommend the flipped classroom model of learning to a friend over the traditional model.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

16. Why did you answer the question above as you did?

17. The traditional classroom model makes better use of my class time.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

18. Why did you answer the question above as you did?

19. I would rather watch the videos at school during class time, knowing I have less time to complete my written work during class.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

20. Why did you answer the question above as you did?

Adapted from: Johnson, G. (2013). Student perceptions of the Flipped Classroom. *University of British Columbia*, 90-92. <http://dx.doi.org/10.14288/1.0073641>

21. The Traditional Classroom gives me enough opportunities to communicate with other students on homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

22. Why did you answer the question above as you did?

23. Why did you answer the question above as you did?

24. My written homework was easier to understand than my video homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

25. I get frustrated at home as I complete my written homework assignments.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

26. Why did you answer the question above as you did?

27. I like how in the Traditional Classroom I take home my traditional written homework to complete by myself.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

28. Why did you answer the question above as you did?

29. I feel I am prepared for the next day when I take my written work home as homework to complete.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

30. Why did you answer the question above as you did?

31. I would recommend the traditional classroom model of learning to a friend over the flipped model.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

32. Why did you answer the question above as you did?

33. The Flipped Classroom model is more engaging than the traditional classroom.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

34. Why did you answer the question above as you did?

35. Watching videos as homework is engaging.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

36. Why did you answer the question above as you did?

Adapted from: Johnson, G. (2013). Student perceptions of the Flipped Classroom. *University of British Columbia*, 90-92. <http://dx.doi.org/10.14288/1.0073641>

37. I am motivated to complete science homework when it involves watching a video to prepare for the next day.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

38. Why did you answer the question above as you did?

39. I completed my traditional written homework more frequently than my video homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

40. Why did you answer the question above as you did?

41. Our Traditional Classroom is more engaging than the Flipped Classroom

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

42. Why did you answer the question above as you did?

43. Completing written homework is engaging.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

44. Why did you answer the question above as you did?

Adapted from: Johnson, G. (2013). Student perceptions of the Flipped Classroom. *University of British Columbia*, 90-92. <http://dx.doi.org/10.14288/1.0073641>

45. I am motivated to complete science homework when it is a written assignment that requires me to reflect on the day's lesson.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Agree
☐	☐	☐	☐	☐

46. Why did you answer the question above as you did?

47. I completed my video homework more frequently than my traditional written homework.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

48. Why did you answer the question above as you did?

49. What science class are you in?

APPENDIX H

STUDENT ENGAGEMENT AND THINKING CHECKLIST

Name _____ Period (Circle One) B - E - F Week ____ Lesson ____

Instructions: Read through each of the following and quickly and accurately rate it.

Gender: Male or Female

Ethnicity (circle those represented): American Indian - Alaskan - Native Asian - Hispanic or Latino -
Black or African-American - Native Hawaiian or Other Pacific Islander - White

Active participation of all was encouraged and valued today.

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

There was a climate of respect for students' ideas, questions, and contributions.

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

You were mentally engaged today with important ideas relevant to the focus of the lesson.

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

The science I learned today was important to me. (*Learning Goal Orientation*)

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

What I learned today encouraged me to think. (*Task Value*)

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

I was good at what I did today in science. (*Self-Efficacy*)

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

I kept focused and worked throughout the class period today. (*Self-Regulation*)

1 (Strongly Disagree) - 2 (Disagree) - 3 (Not Sure) - 4 (Agree) - 5 (Strongly Agree)

What was your engagement level in the classroom today? __Engaged __On-Task __Off-

How much time did you spend completing science homework? (Check One)

____0-15 minutes ____16-30 minutes ____31-45 minutes

____46-60 minutes ____More than an hour

Did you complete your homework? ____Yes ____No

What is the primary level of thinking required of you today? (Check One)

____Low

(Knowledge and
Comprehension)

- Knowledge is defined as the remembering of previously learned material.
- Comprehension is defined as the ability to grasp the meaning of material

____Middle

(Application
and Analysis)

- Application refers to the ability to use learned material in new situations
- Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood. May involve comparing and contrasting.

____High

(Synthesis and
Evaluation)

- Synthesis refers to the ability to put parts together to form a new whole, new idea.
- Evaluation is concerned with the ability to judge the value of material (statement, novel, poem, research report) for a given purpose

Adapted from:

Look2Learning:<http://images.pcmac.org/Uploads/MeadeCounty/MeadeCounty/SubDepartments/DocumentsSubCategories/Documents/E1.3.a%20L2L%20-%20Tally%20Sheet.pdf>

Horizon Research, Inc. Inside the Classroom: Observation and Analytic Protocol – “Inside the Classroom Observation and Analytic Protocol

APPENDIX I
STUDENT UNIT FEEDBACK SURVEY

Note: This version is for the traditional classroom. For the flipped classroom, question #1 was changed to “I was satisfied with the current FLIPPED homework model as a way of completing homework.”

Student Unit Feedback Survey											
Student Unit Feedback Survey											
This survey provides your teacher with feedback on this mini unit - learning how to do science investigations. SUB QUESTION 1: To what extent does the flipped classroom impact student engagement? SUB QUESTION 2: What perceptions do students have about flipped classroom as compared to the traditional classroom? SUB QUESTION 3: In what ways does the flipped classroom impact my classroom pedagogy in an international school? Participation in this research is voluntary and participation or non-participation will not affect a student's grade or class standing in anyway. Please answer each question to the best of your ability.											
* 1. I was satisfied with the current TRADITIONAL homework learning model as a way of completing homework. <table border="1"> <thead> <tr> <th>Strongly Disagree</th> <th>Disagree</th> <th>Not Sure</th> <th>Agree</th> <th>Strongly Agree</th> </tr> </thead> <tbody> <tr> <td>☐</td> <td>☐</td> <td>☐</td> <td>☐</td> <td>☐</td> </tr> </tbody> </table> Why did you respond the way you did to the above question?		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree	☐	☐	☐	☐	☐
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree							
☐	☐	☐	☐	☐							
* 2. I was focused and on task throughout the unit. <table border="1"> <thead> <tr> <th>Strongly Disagree</th> <th>Disagree</th> <th>Not Sure</th> <th>Agree</th> <th>Strongly Agree</th> </tr> </thead> <tbody> <tr> <td>☐</td> <td>☐</td> <td>☐</td> <td>☐</td> <td>☐</td> </tr> </tbody> </table>		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree	☐	☐	☐	☐	☐
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree							
☐	☐	☐	☐	☐							
3. I was focussed and on task in class about this percentage of time. ☐ More than 75% of the time ☐ Between 50% and 75% of the time ☐ Between 25% and 50% of the time ☐ Less than 25% of the time											

Modified for educational purposes from edutopia.org: <http://www.edutopia.org/resource/trinidad-garza-student-feedback-survey-download>

* 4. I would prefer my homework to be:

☐ Completing a "Making Sense of It" assignment that reviews the day's lesson

☐ Watching a video that introduces the next day's lesson

* 5. In this unit with regards to homework completed outside of class time I was able to successfully complete my required homework.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

Why did you respond the way you did to the above question?

* 6. If I needed to, I was able to get help from others to complete my homework.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

Why did you respond the way you did to the above question?

* 7. I was challenged to think critically (think deeply, apply my learning, think creatively, and/or make connections) on my "making sense of it" assignment

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

Why did you respond the way you did to the above question?

* 8. I would prefer watching videos that introduce me to the next day's lesson as homework and review concepts by completing higher-order thinking assignments during class - not at home.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

Modified for educational purposes from edutopia.org: <http://www.edutopia.org/resource/trinidad-garza-student-feedback-survey-download>

* 9. I completed my homework consistently each night.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

* 10. Think through your "making sense of it" assignments, what level did you perform most consistently at? (circle the level)

☐ LEVEL 5 (Exceeding Standard)

I can reflect exemplary with details and make connections to the real world using scientific understanding. My work shows evidence of higher order thinking and evidence of impressive, in-depth connections. I can apply my knowledge to new ideas in ways that show understanding. I can use detailed and labeled drawings or webs to show clear connections.

☐ LEVEL 4 (Met Standard)

I can reflect proficiently with some details and make connections to the real world using scientific understanding. My work shows evidence of higher order thinking and evidence of many well, explained connections. I can apply my knowledge to new ideas in ways that show some understanding. I can use drawings or webs to show connections. Sometimes my drawing or explanations lack clarity or depth.

☐ LEVEL 3 (Basic, Not Yet Met)

I can reflect at a basic level and show some connections, but with limited evidence or elaboration, connections, extension, higher-order thinking and/or reflection about the subject. Illustrations and webs may not always show clear connections.

* 11. What is most difficult for you to do from the above rubric? Rank the difficulty level from **MOST DIFFICULT TO LEAST DIFFICULT**

	Reflecting on an assignment
	Applying a concept to new ideas and understandings
	Connecting ideas to the real-world
	Using visuals to connect or show understanding

* 12. If I needed help on the "making sense of it" assignment, I was able to seek feedback from my teacher and peers.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

Modified for educational purposes from edutopia.org: <http://www.edutopia.org/resource/trinidad-garza-student-feedback-survey-download>

13. Each day's activities provided me with the necessary understandings to successfully complete my "making sense of it" assignments.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
☐	☐	☐	☐	☐

What made you say that?

* 14. Thinking about our learning in this unit and our daily focus on higher-order thinking, it would be helpful to my learning if my teacher spent MORE TIME...

* 15. Thinking about our learning in this unit and our daily focus on higher-order thinking, it would be helpful to my learning if my teacher spent LESS TIME...

APPENDIX J

STUDENT FOCUS GROUP INTERVIEW

SUB QUESTION 2: What perceptions do students have about flipped classroom as compared to the traditional classroom?

Participation in this research is voluntary and participation or non-participation will not affect a student's grade or class standing in anyway. The recording will only be used for research purposes and will not be shown to anyone but the researcher.

#1. What are the advantages of the flipped classroom? What did you like? Why?

#2. What are the disadvantages of the flipped classroom? What did you not like? Why?

#3. Was it advantageous for you to have more time in class to work on written work?

Explain.

#4. Which do you prefer: working on written homework at home or watching a video that introduces the next day's lesson at home. Why?

#5. What improvements would you recommend to improve learning in the flipped classroom?

#6. If you could choose between a flipped classroom similar to the model we used and a traditional science classroom, which would you choose and why?

#7. Was there anything on the flipped classroom survey that you would like to address?

*Record the interview. Record down demographic information.

APPENDIX K
IRB EXEMPTION

MONTANA STATE UNIVERSITY
Request for Designation of Research as Exempt
MSSE Research Projects Only
 (6/16/14)

 THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT WRITE IN THIS AREA.

Confirmation Date: 8/29/16 Mark J. G.
 Application Number: _____

DATE of SUBMISSION: 8/27/2016

Address each section – do not leave any section blank.

I. INVESTIGATOR:

Name: Craig Gingerich
 Home or School Mailing Address:
Concordia International School Shanghai 999 Mingyue Rd, Pudong, Shanghai, China
 Telephone Number: 208-639-0604
 E-Mail Address: craig.gingerich@concordiashanghai.org
 DATE TRAINING COMPLETED: 03/03/2016
 Investigator Signature: Craig Gingerich
 Name of Project Advisor: Walter Woolbaugh
 E-Mail Address of Project Advisor: walter.woolbaugh@ecat.montana.edu

- ok as exempt
 - MSSE Classroom assessment
 - Little/no risk
 - Principal approved
 - No concerns
 MEJ
 8/29/16

II. TITLE OF RESEARCH PROJECT:

The Effect of a Flipped Science Classroom on Student Achievement and Motivation

III. BRIEF DESCRIPTION OF RESEARCH METHODS (If using a survey/questionnaire, provide a copy).

Primary Question

1. How does flipping the classroom impact student's higher-level understanding?

Sub Questions

2. To what extent does the flipped classroom impact student engagement?
3. How do students perceive the flipped classroom compared to the traditional classroom?
4. How does the flipped classroom impact my pedagogy?

Methodology

The capstone will involve three grade seven science classes as they go through the *Science and Engineering Practices Unit*. All three classes will begin with the non-treatment for two weeks using the traditional model where written homework (higher level) is sent home, and end with the treatment for four weeks where homework becomes an introduction (low level) video/digital assignment that introduces students to the following day's topic.

The science and engineering practices unit utilizes a template called *A Tool for Storyline Coherence*. This storyline is broken into four phases: questions; phenomena; practice engagement; sense making.



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Craig Gingerich and Walt Woolbaugh

FROM: Mark Quinn *Mark Quinn*

DATE: August 29, 2016

RE: "The Effect of a Flipped Science Classroom on Student Achievement and Motivation" [CG082916-EX]

The above research, described in your submission of **August 29, 2016**, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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